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Detection of Gold Mineralization and Lithologic Mapping Within the Agassiz Metallotect (Lynn Lake Area) Utilizing Black Spruce (Picea mariana) Bark

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ABSTRACT

A geochemical study of 74 bark samples of black spruce *(Picea mariana)* collected from a single transect over a known Au-As occurrence in the Lynn Lake area is described. The analyses indicate that spatially restricted zones of Ba depletion (30 m) and As enrichment (30 m) are present in the bark samples but these haloes are only marginally wider than the mineralized zone (20 m). The ratio Zn/Ba, however, apparently delineates a 250 m enrichment halo associated with the mineralization. The high Mg-Ni-Cr basalts associated with the Au-As occurrence are effectively delineated by the elements Ni, Cr and Co in the bark samples with anomalous to background contrast ratios of 2:1, 1.6:1 and 3:1, respectively. Element ratios are generally no more informative, with the exception of Zn/Ba, than single elements for the bark geochemical definition of the host rocks. False geochemical anomalies along the sampling transect for the elements Mn and Au are shown to be related to drainage effects indicating the importance of standardizing topography during sampling.

INTRODUCTION

The collection of various organs of a wide range of vegetation types, the subsequent geochemical analysis of these samples and the application of the results to problems of mineral exploration are becoming routine. Vegetation geochemical surveys are being undertaken on both regional and local scales (Dunn, 1986) in the ongoing development of geochemical techniques applicable to gold exploration in the northern areas of Canada.

This study of metal content of the outer bark of black spruce *(Picea mariana)* follows previous studies (Fedikow, 1984; 1986) designed to examine the contrast in metal content of black spruce needles and twigs and Labrador tea *(Ledum groenlandicum)* leaves and twigs in samples collected over gold mineralization as well as apparently barren rock. Ultimately, the intent of these studies is the development of vegetation geochemical gold exploration techniques applicable to northern Manitoba. More specifically, the techniques are being developed to assist exploration of the Agassiz Metallotect, a 65 km long zone of interlayered biotitic and siliceous siltstone, amphibolitic greywacke and high Mg-Ni-Cr basalt, that hosts numerous gold occurrences, one promising gold deposit (Farley Lake-Wendy Zone) and one deposit in production (MacLellan Au-Ag deposit).

A total of 74 bark samples of black spruce were collected over a period of two days in June, 1985, from a single 800 m long transect over the Rushed Au-As occurrence at Dot Lake, west of the MacLellan Au-Ag deposit (Fig. 1, 2). Samples for the bark survey were collected from the same transect as were black spruce needles and twigs from a previous vegetation geochemical study (Fedikow, 1984). Results of this study will permit the examination of the variation in concentration of a number of trace elements in outer scaly bark of black spruce in the vicinity of the Rushed mineralized zone. The use of the outer, scaly bark as a geochemical exploration sampling medium for gold, and the application of bark geochemistry as a lithologic mapping tool in defining the high Mg-Ni-Cr MacLellan "picrite" in areas of no outcrop within the Agassiz Metallotect are presented.

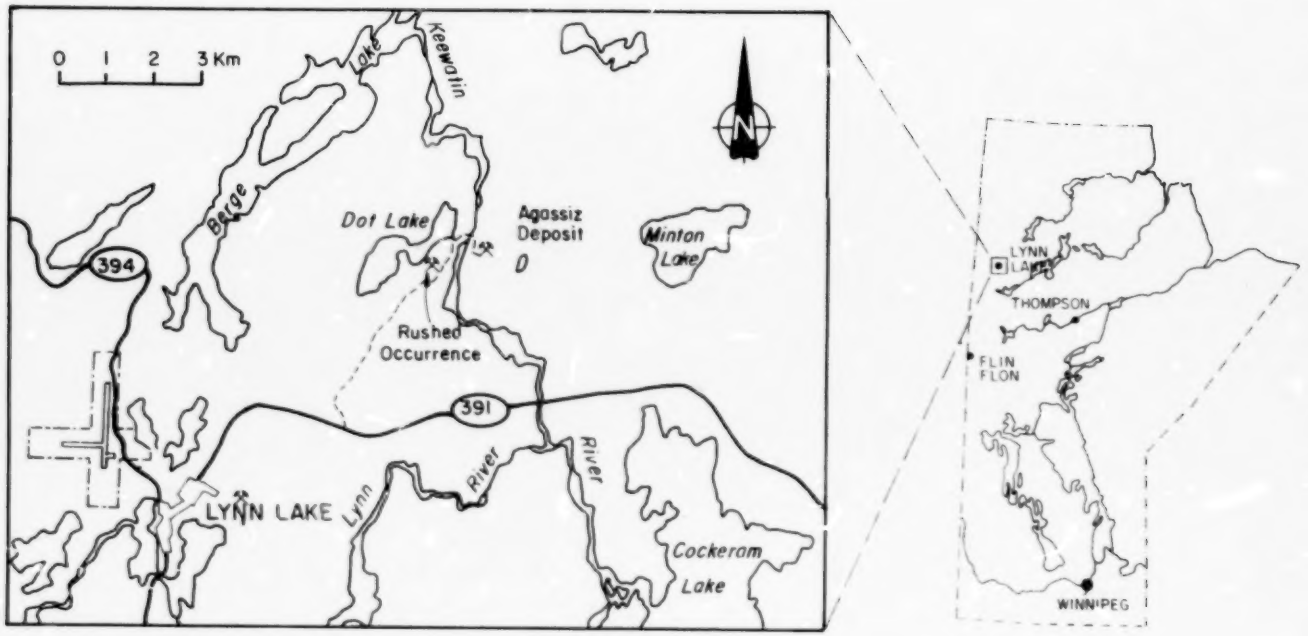
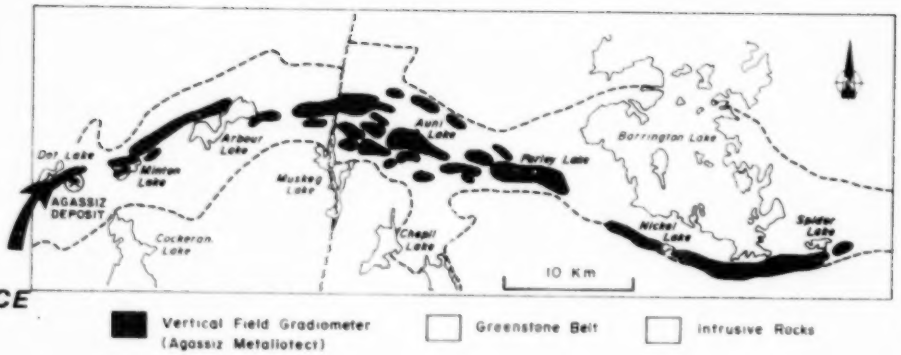


Figure 1: Location map for the Rushed Au-As occurrence and the Agassiz Au-Ag deposit (now MacLellan Mine).



RUSHED Au - As OCCURRENCE

Figure 2: Location map for the study area in relation to the Agassiz Metallotect.

GEOLOGY

The Rushed Au occurrence and host rocks form part of the Agassiz Metallotect (Fedikow, 1986). This distinctive sequence of interbedded clastic sedimentary rocks and high Mg-Ni-Cr basalts host the MacLellan Au-Ag deposit and the Farley Lake (Wendy Zone) Au deposit eastwards along its 65 km strike length. The Agassiz Metallotect lies within Division D of the Wasekwan Group volcanic and sedimentary rocks in the northern belt of the Aphebian Lynn Lake greenstone belt (Gilbert et al., 1980).

The local geology of the area is characterized by interbedded clastic sedimentary rocks and two distinct sequences of basalt. One basalt sequence comprises fragmental, amygdular, aluminous (greater than 18% Al_2O_3) basalts, and the second basalt sequence is represented by massive and fragmental high Mg-Ni-Cr basalts. The latter basalt sequence constitutes the MacLellan "picrite". In proximity to the Rushed Au showing the rocks are characteristically rusty weathered, fractured and sheared clastic sedimentary rocks; the mineralization and accompanying wallrock alteration have effectively focussed deformation in the area. The host rocks to the Rushed Au occurrence are steeply dipping (80-85^{o}N) greywacke and andesitic tuffaceous rocks flanked by aluminous basalt to the north and south. Thin oxide facies iron formation (magnetite-chert) is interbedded with the aluminous basalt south of the occurrence. The stratigraphy in the vicinity of the occurrence is given in Figure 3 which provides a geological section from the structural footwall on the south to the structural hanging wall on the north. This stratigraphy is summarized and plotted at the bottom of the bark geochemical profiles in Figures 4 through 19.

The Rushed occurrence mineralization is characterized by 30-60% pyrite, pyrrhotite, arsenopyrite, magnetite, chalcopyrite and sphalerite containing 0.02 to 0.10 oz/ton gold. The mineralized zones range in thickness from 0.2-1.0 m and are traceable along strike for 1200 m. Visible gold has not been observed at the occurrence; gold content is proportional to the amount of arsenopyrite present in the mineralization (Audet, 1983). Trace element geochemical analyses of two grab samples, collected from the surface exposure of the occurrence, are reproduced in Table 1. The low Hg contents of

the mineralization were reflected by the negative results of a Hg-gas survey conducted over the mineralized zone (Fedikow, 1985).

The Dot Lake area, including the Rushed occurrence, has most recently been the focus of gold exploration activity by Sherritt Gordon Mines Ltd., Lynn Lake. Geological mapping, geophysical and geochemical studies have all been undertaken in the area. Honours B.Sc. theses by Audet (1983) and Brack (1983) describe the geology, mineralization and rock geochemical studies in the Dot Lake area. Evaluation of mineralized zones on the property is ongoing.

TABLE 1

TRACE ELEMENT GEOCHEMICAL ANALYSES OF TWO SAMPLES (00602, 00603) OF RUSHED OCCURRENCE MINERALIZATION. ANALYSES IN PPM UNLESS OTHERWISE NOTED

	ELEMENT	00602	00603
Neutron Activation (INAA)	Cr	40	21
	Fe(%)	21.9	8.3
	Co	45	110
	Ni	420	100
	Zn	3000	2000
	As	83	>3000
	Se	8	<6
	Mo	19	<3
	Ag	<2	<2
	Cd	9	<9
	Sb	0.7	18.2
	Ba	330	830
	La	8	5
	Hf	1	<1
	Ta	<0.5	<0.5
	W	<10	<10
	Ir (ppb)	<50	<50
	Au (ppb)	180	595
	Th	1.5	1.3
	U	4.8	2.2
Atomic Absorption (AAS)	Cu	468	104
	Pb	16	120
	Zn	2900	1750
	Cd	10	16
	Ag	2.2	1.2
	Ni	315	90
	Co	28	79
	Mo	19	7

SAMPLING, SAMPLE PREPARATION AND ANALYSIS

Outer scales of the bark of black spruce were collected at 10 m intervals along a transect perpendicular to the strike of the rock units hosting the Rushed mineralization (Fig. 3). The sampling interval was reduced to 3 m within 25 m of either side of the mineralized zone. Each sample represents the outer scaly bark of five black spruce trees within 1-2 m of the sampling point. Bark scales were removed from around the tree with a knife for a 1 m section of the trunk starting at eye level (between 1.5 and 1.8 m) and working downwards. Generally the black spruce trees sampled were of uniform diameter and similar vigour in the study area. Depth to bedrock is generally less than 1 m and is characterized by sandy till, humus and humified peat topped by sphagnum. The bark collected from each of the five trees was bulked to give a single sample. This particular sampling technique was employed to try to avoid the unequal trace element distribution that exists in a single tree owing to the root specific supply of metals to the twigs and needles, and which ultimately reside in the scaly, outer bark (Brooks, 1972). The outer scaly bark of black spruce is effectively dead tissue. Subsequently, metal contents in this bark should be static and not be affected by seasonal or month-to-month fluctuations of metals as in the case of leaves, needles and twigs. Samples were analyzed for Cu, Pb, Zn, Cr, Ni, Co, Fe, Mn and Ba in ash by AAS and for Au and As in unashed briquettes by INAA. All analyses were undertaken by Bondar Clegg Ltd., Ottawa.

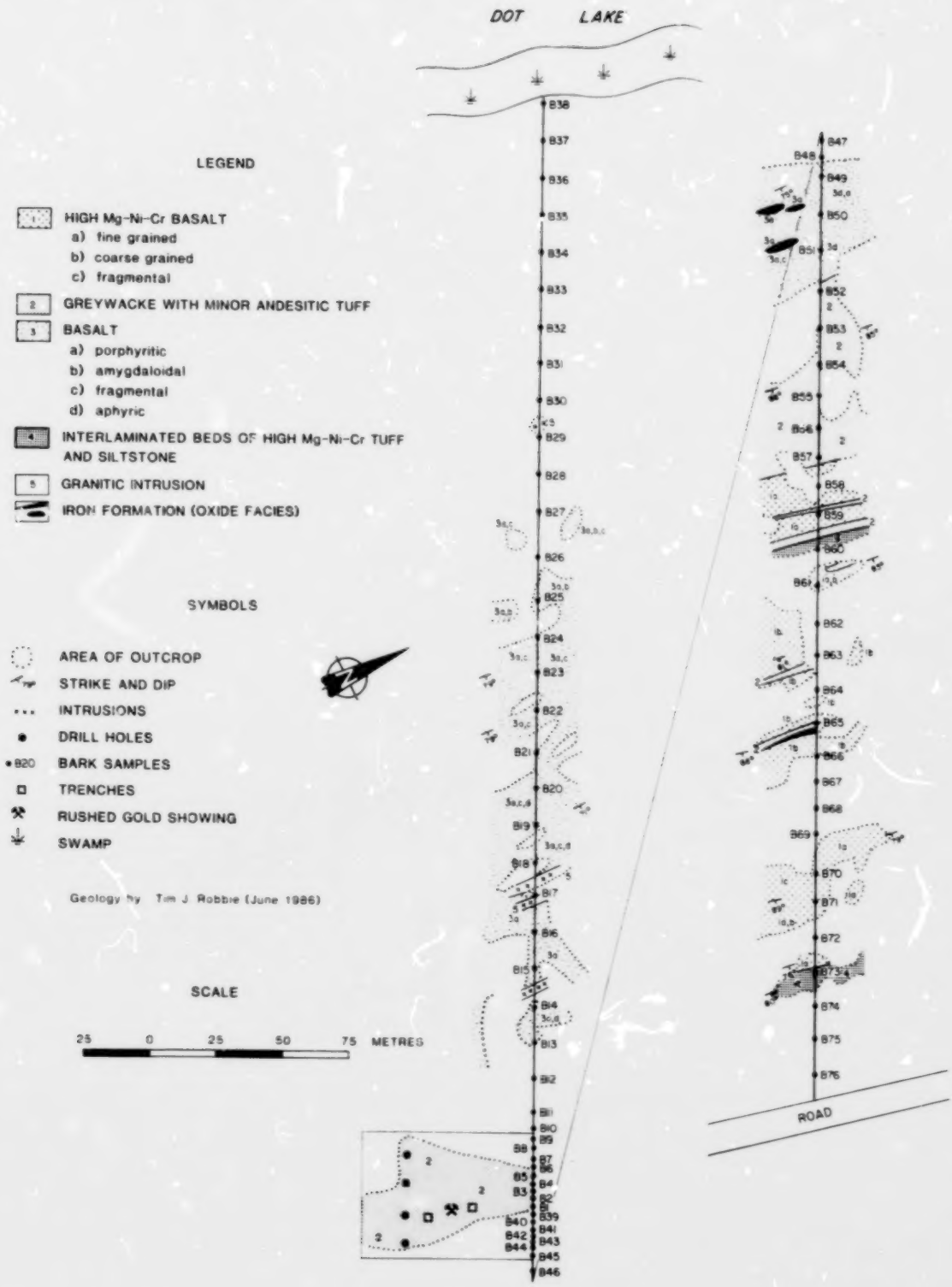


Figure 3: Outcrop and geology map of the Rushed occurrence and the location of black spruce bark samples.

RESULTS AND OBSERVATIONS

Introduction

Raw analytical data from the bark analyses are presented in Appendix I along with analytical specifications. Determination of threshold was accomplished using the graphical solution of Tennant and White (1959) and results for each element are presented in Appendix II. Histograms illustrating the nature of data distribution are given in Appendix III. Examination of the variation in metal content of the bark samples with proximity to the mineralized zone is accomplished using X-Y profiles over the Rushed occurrence with a simplified geological section along the x-axis accompanying each plot. The geological section permits comparison of bark metal contents with respect to underlying rock type and with proximity to mineralization.

Data Description

Descriptive statistics for the analytical data representing the bark analyses are summarized in Table 2. Casual inspection of the arithmetic means for these data reveals the following order of decreasing abundance in the bark:

Fe > Mn > Zn > Cu > Ni > Pb > Ba > Cr > Co > As > Au

The scatter or standard deviations of the analyses exhibit considerable overlap between some of the elemental abundances. This scatter of chemical data is related to a number of factors:

1. numerous sub-populations of data within the overall population: e.g., Cr, Ni and Co in bark samples collected over high Mg-Ni-Cr basalts are significantly higher than the abundances of these elements in bark samples collected over aluminous basalts. This point is discussed further in the section on single element profiles over the mineralized zone;

2. higher Zn and As and lower Ba in the bark samples with proximity to the mineralized zone impart an increased scatter to the chemical data;
3. the effects of drainage and the concomitant increase in Mn and Au mobility in poorly drained substrate are further contributors to the scatter of the Mn and Au data. High Mn and Au contents are recorded from bark samples collected over boggy ground along the sampling transect.
4. chromium analyses are characterized by the widest scatter in the elements determined in ash of the black spruce bark samples, possibly reflecting the resistate nature of chromium and the difficulty in vegetation uptake of this element.

The presence of multiple data populations is reflected in the histograms which indicate a positively skewed distribution more closely approximating lognormality; Cu and Pb may be exceptions. These multiple populations are reflected in the graphical solution of threshold utilized in this survey. Threshold determinations are presented in Table 2 and the graphs in Appendix II and this technique is satisfactory when there are two populations present in the data set, i.e., the lower concentration population is assumed to represent the "background" population. This particular technique is limited when multiple (i.e. more than two) data populations are present in the same data set. A decision as to whether the threshold value is deduced using either the first and second populations, or at the break between the second and third populations is subjective. In this study the threshold was selected at the location of the first significant or obvious "break" in the graph. Despite this method of selection some thresholds were selected at obviously incorrect levels. For instance, the threshold for Ba (see Fig. 4) was clearly selected at too low a value even though the first major break on the threshold graph occurs at 50 ppm. A more suitable determination might be to use a concentration range for the threshold. For instance, in the case of Ba the first break occurs at 50 ppm and the second at 59 ppm (Appendix II); therefore, the threshold would be stated as 50-59 ppm. This determination would be innacurate if multiple data populations are present. The determination of threshold may best be undertaken by examination of histograms, descriptive statistics and, then, interpretation of graphical solutions in light of all observed parameters.

TABLE 2

STATISTICAL SUMMARY OF ANALYTICAL DATA FOR 74 SAMPLES OF BLACK SPRUCE *(PICEA MARIANA)* BARK, RUSHED Au SHOWING, LYNN LAKE AREA.
ANALYSES IN PPM UNLESS OTHERWISE NOTED

ELEMENT	MEAN (ARITHMETIC)	STANDARD DEVIATION	RANGE	VARIANCE	SKEWNESS	KURTOSIS	THRESHOLD
Cu	1061	289	281-1699	83381	0.125	0.229	1400
Pb	141	41	43-234	1682	-0.120	-0.225	138
Zn	2523	487	1624-4088	237060	0.695	0.286	2650
Ni	660	185	336-1422	34405	1.149	3.009	820
Cr	31	125	6-64	125	0.777	0.808	26
Co	24	9	10-59	74	1.377	3.493	28
Fe(%)	1.6	0.6	0.3-3.1	0.3	0.527	0.452	1.95
Mn	5244	1966	2240-11570	3865002	1.208	1.423	4000
Ba	69	15	43-118	236	0.402	0.061	50
Ash(%)	2.1	0.5	1.25-4.24	0.213	1.676	6.070	2.6
Au(ppb)	1.4	2.0	0.4-19.0	5.160	6.768	51.429	1.8
As	0.7	0.8	0.1-5.0	0.613	3.731	15.997	1.2

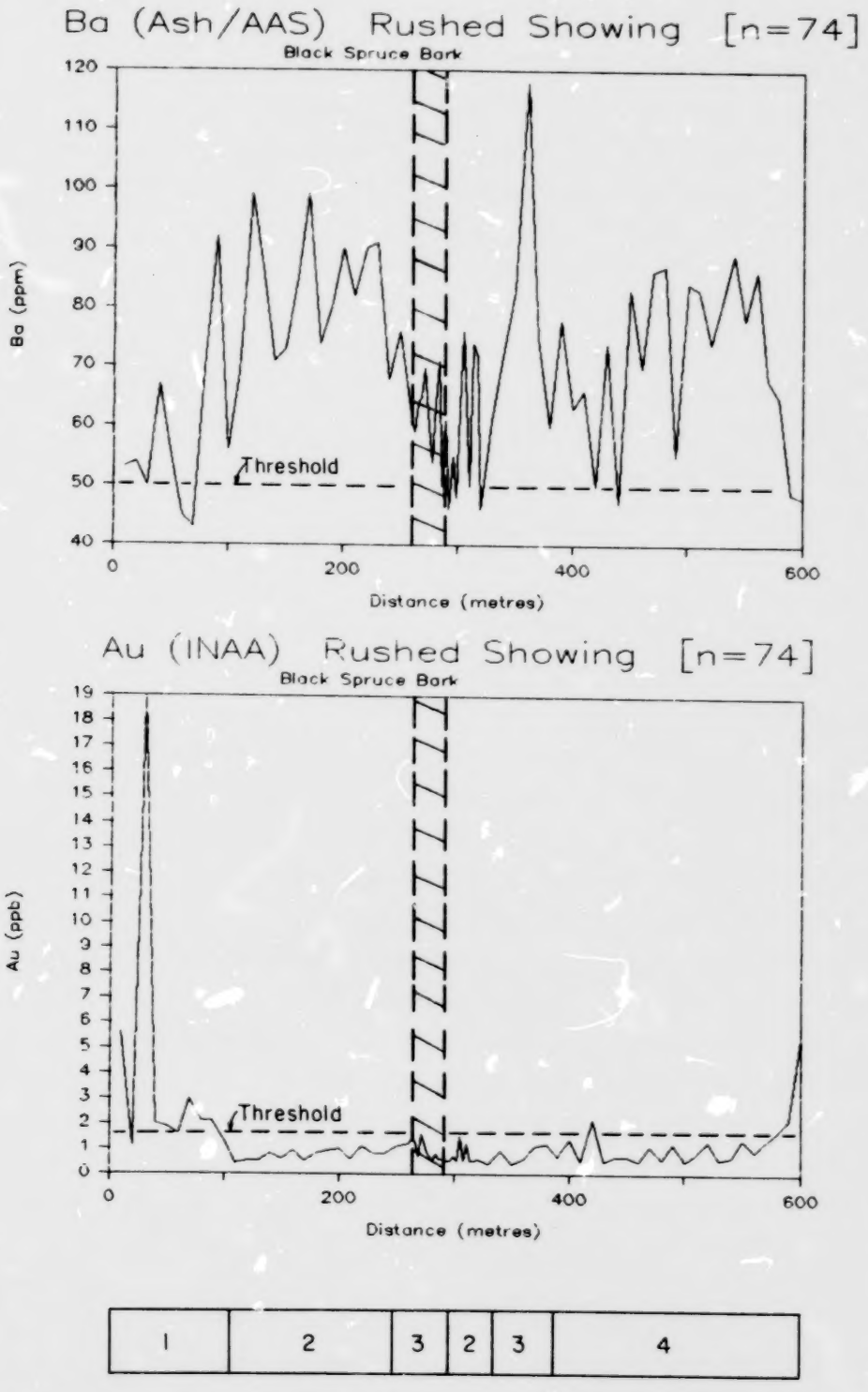


Figure 4: Ba and Au contents in ash of black spruce bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by vertical dashed lines. Legend for geological section as follows: 1-granite, 2-aluminous basalt, 3-clastic sedimentary rocks, 4-high Mg-Ni-Cr basalt (picrite).

Correlation Coefficients

A Pearson correlation coefficient matrix was calculated for the black spruce bark geochemical data set. The matrix is reproduced in Table 3 and significant positive and negative element pair correlations summarized for ease of inspection in Table 4.

Significant positive correlations between element pairs are heavily weighted towards the association of sulphide-forming elements (Cu, Pb, Zn, Fe, As, Co) and the Ni-Cr association of the high Mg-Ni-Cr basalts that characterize part of the substrate in the study area. Sulphide mineralization at the Rushed occurrence and within the high Mg-Ni-Cr basalts is characterized by sphalerite, pyrite, pyrrhotite, arsenopyrite and, to a lesser extent, chalcopyrite and galena. Positive correlations between paired elements in bark geochemical data correlate with bedrock-sulphide associations. The positive Mn-Au correlation reflects the increase in the mobility of both elements in boggy, poorly drained substrate and their subsequent uptake and deposition in black spruce bark. The As-Ash correlation reflects the coincident anomaly for these two elements between 580 and 600 m along the sampling transect which extends over part of the MacLellan host basalts. The reason for coincident high contents for these two parameters is unknown, unless increased As in the vegetation, acquired from bedrock mineralization or overburden, alters chemical processes in the tree which are reflected in the ash per cent of the bark. A simpler explanation for both the positive element correlation between As and Ash as well as the apparent anomalies at this point along the sampling transect may be particulate contamination from the MacLellan deposit access road. This road passes within 5 m of the sampling transect. Accordingly, As from the mine muck used to construct the road may have settled on the bark of the adjacent trees. This additional particulate matter would tend to increase ash per cent in the bark samples.

Significant negative correlations in element pairs of the bark geochemical data are overwhelmingly influenced by the association of Mn with Cu, Pb, Fe, As (sulphide association), Cr (high Mg-Ni-Cr basalts) and Ba. This factor may indicate that Mn uptake is influenced by different

physicochemical characteristics (i.e. pH) related to drainage characteristics of the area, and differs markedly from the behaviour of the other elements. The absence of Mn in positive correlation element pairs further substantiates this hypothesis. Au and Mn appear to exhibit similar migration characteristics in poorly drained substrate.

Single Element and Element Ratio Profiles

The patterns and relative abundances of trace metals in black spruce bark are discussed in terms of (1) proximity to the Rushed mineralization, (ii) the variation in the nature of the bedrock within the substrate and (iii) drainage characteristics in the study area.

(i) Proximity to Mineralization

With proximity to the Rushed mineralization there is a limited number of indicator elements in the bark samples that effectively delineate the zone or give a halo effect. An erratic, narrow zone of Ba depletion exists in bark samples with values ranging from 47-65 ppm flanked by highs of 70-100 ppm to the north, and 70-110 to the south (Fig. 4). This depletion anomaly is not much wider than the mineralized zone and would require a 3-5 m sampling interval to define it during property-scale evaluation. An equally narrow zone of As enrichment (Fig. 5) is observed in the samples associated with the mineralization. The anomaly is characterized by values between 1.5-5 ppm As contrasted with a background of less than 1 ppm. A second As anomaly is located to the south of the Rushed mineralization between 580 and 600 m. This anomaly is marked by As contents of 1.5 to about 4 ppm and corresponds approximately to the stratigraphically lower MacLellan deposit host rocks. The As data, therefore, delineate anomalous As concentrations in association with both the Rushed and possibly the MacLellan mineralization. The extent of the "MacLellan" anomaly is undetermined. Once again the "Rushed" As anomaly is effectively restricted to the immediate vicinity of the mineralized zone and requires numerous, closely spaced samples to define it.

TABLE 3

MATRIX FOR PEARSON CORRELATION COEFFICIENTS, BLACK SPRUCE *(PICEA MARIANA)* BARK. ASTERISK INDICATES A SIGNIFICANT CORRELATION AT THE 99% CONFIDENCE LEVEL

	Cu	Pb	Zn	Ni	Cr	Co	Fe	Mn	Ba	Au	As	Ash
Cu	1.0000	.7996*	.1185	.7293*	.7013*	.5597*	.7926*	.3255*	.0052	-.0966	.2344	-.0008
Pb	.7996*	1.0000	-.1672	.6232*	.6050*	.4997*	.7742*	.4992*	.0614	-.1442	.2353	.0215
Zn	.1185	-.1672	1.0000	.0370	-.0311	-.0121	-.0761	.2210	-.0572	.0518	.0200	-.1827
Ni	.7293*	.6232*	.0370	1.0000	.4636*	.8551*	.5212*	.2035	.0457	.0548	.0540	-.0333
Cr	.7013*	.6050*	.0311	.4636*	1.0000	.3776*	.9075*	.4061*	.1185	.0889	.4236*	.2952*
Co	.5597*	.4997*	.0121	.8551*	.3776*	1.000	.3608*	.0961	-.0854	.0577	.0374	.1195
Fe	.7926*	.7742*	.0761	.5212*	.9075*	.3608*	1.0000	.5553*	-.1330	-.0556	.5107*	.2002
Mn	-.3255*	.4992*	.2210	-.2035	-.4061*	.0961	.5533*	1.0000	.1156	-.4066*	.3713*	.0075
Ba	.0052	.0614	-.0572	.0457	-.1185	.0854	.1300	.1156	1.0000	-.2683	-.2466	-.4450*
Au	-.0966	-.1442	.0578	-.0548	.0889	.0577	-.0556	.4066	-.2683	1.0000	-.0271	-.2181
As	.2344	.2353	.0200	-.0540	.4236*	-.0374	-.5107*	.3713*	-.2466	-.0271	1.0000	-.2951*
Ash	-.0008	.0215	-.1827	-.0333	.2952*	-.1195	-.2002	.0075	-.4450*	.2181	-.2951*	1.0000

TABLE 4

SUMMARY OF SIGNIFICANT POSITIVE AND NEGATIVE ELEMENT PAIRS BASED ON PEARSON CORRELATION COEFFICIENTS AT THE 99% LEVEL OF CONFIDENCE, BLACK SPRUCE *(PICEA MARIANA)* BARK, RUSHED OCCURRENCE, LYNN LAKE AREA

Significant (99%) Positive Element Correlations	Significant (99%) Negative Element Correlations
Cu-Pb, Co-Cr	Cu-Mn
Cu-Cr, Co-Fe	Pb-Mn
Cu-Ni, Fe-Cr	Cr-Mn
Cu-Co, Fe-Co	Fe-Mn
Cu-Fe, Fe-As	Mn-As
Pb-Ni, Mn-Au	Ba-Mn
Pb-Cr, As-Ash	Ash-Ba
Pb-Co	
Pb-Fe	
Ni-Cr	
Ni-Co	
Ni-Fe	
Cr-As	
Cr-Ash	

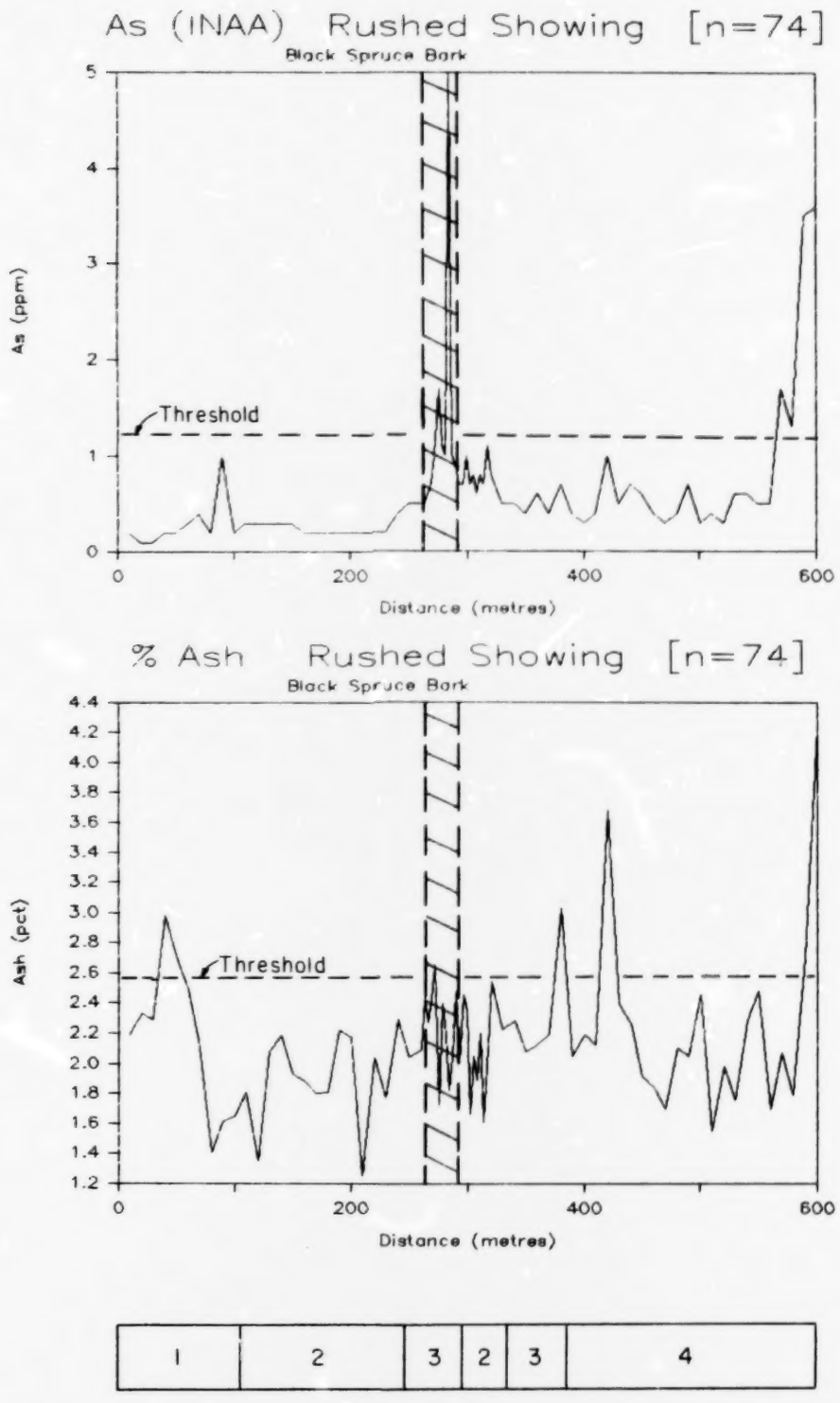


Figure 5: As and ash contents in black spruce bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by vertical dashed lines. Legend for geological section as follows: 1-granite, 2-aluminous basalt, 3-clastic sedimentary rocks, 4-high Mg-Ni-Cr basalt (picrite).

A broad (about 175 m) but tenuous Zn enrichment is proposed for the bark samples collected over the Rushed occurrence. The Zn data are extremely erratic; nevertheless, a cluster of samples containing 3000-4000 ppm Zn over the mineralized zone are distinct compared to scattered single sample peaks of 2700-3300 ppm Zn (Fig. 6). The proposed anomaly also has a higher number of samples that are above the graphically determined Zn threshold of 2650 ppm. The remainder of the elements determined in this study were non-diagnostic of the Rushed mineralization or the MacLellan stratigraphy (see Fig. 4-9).

Element ratios were ineffective in delineating significant zones of enrichment and depletion with the exception of the Zn/Ba results. This profile, depicted in Figure 10, produces a less erratic or "quieter" profile than either Zn or Ba and indicates a well defined 175 m wide enrichment which can be extended to approximately 250 m if a single sample "depletion" at 380 m is rejected. A second anomaly between 0 and 100 m on the transect is related to boggy, poorly drained substrate resulting in increased Zn mobility and subsequent uptake by the black spruce. The Au and Mn anomalies between 0 and 100 m (Fig. 4 and 8, respectively), which correspond in location to the Zn anomaly, appear to substantiate the change in trace element mobility and uptake by vegetation.

(ii) Lithologic Control of Bark Geochemical Profiles

A striking similarity between the bark geochemical trends for many of the elements determined in this study is displayed in Figures 5 through 9. A trend of higher element concentrations between 260-600 m (as compared to 0-260 m) is observed for Fe (1.8-3.0% versus 0.6-1.7%; Fig. 8), Cu (1000-1700 ppm versus 500-1100 ppm; Fig. 9), Pb (140-230 ppm versus 60-140 ppm; Fig. 9), Cr (26-60 ppm versus 10-30 ppm; Fig. 7), Co (20-60 ppm versus 10-20 ppm; Fig. 7), As (0.1-5 ppm versus 0.1-1 ppm; Fig. 5) and Ni (600-1400 ppm versus 400-600 ppm; Fig. 6). Mn, Ba and Au results do not reflect these changes. The changes in element concentrations from right to left on Figures 4 through 9 in Fe, Cu, Pb, Cr, Co, As and Ni are considered to represent the effects of both mineralization and changing rock type. For instance, those samples collected over the MacLellan high Mg-Ni-Cr basalt clearly contain higher Ni

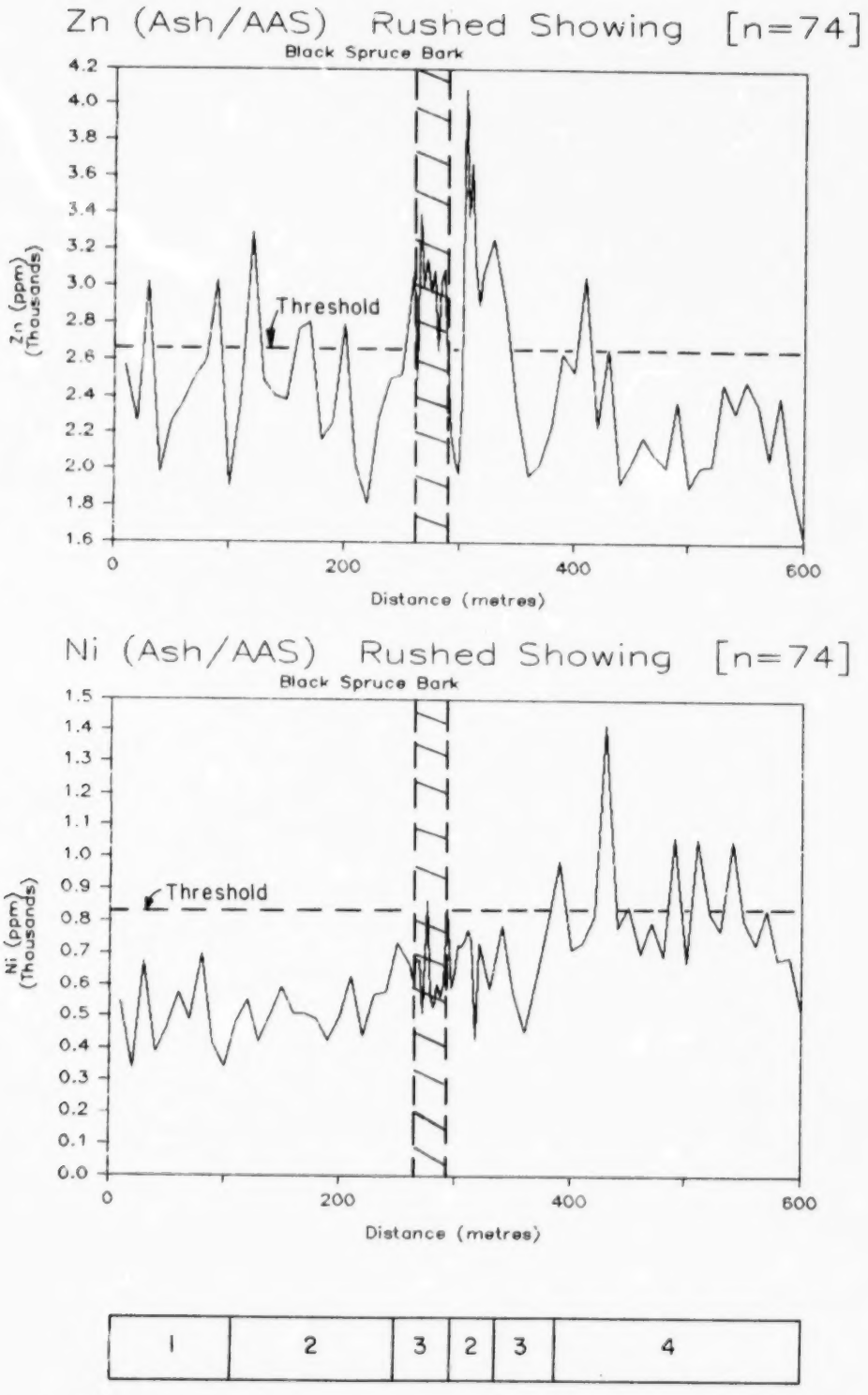


Figure 6: Zn and Ni contents in ash of black spruce bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by vertical dashed lines. Legend for geological section as follows: 1-granite, 2-aluminous basalt, 3-clastic sedimentary rocks, 4-high Mg-Ni-Cr basalt (picrite).

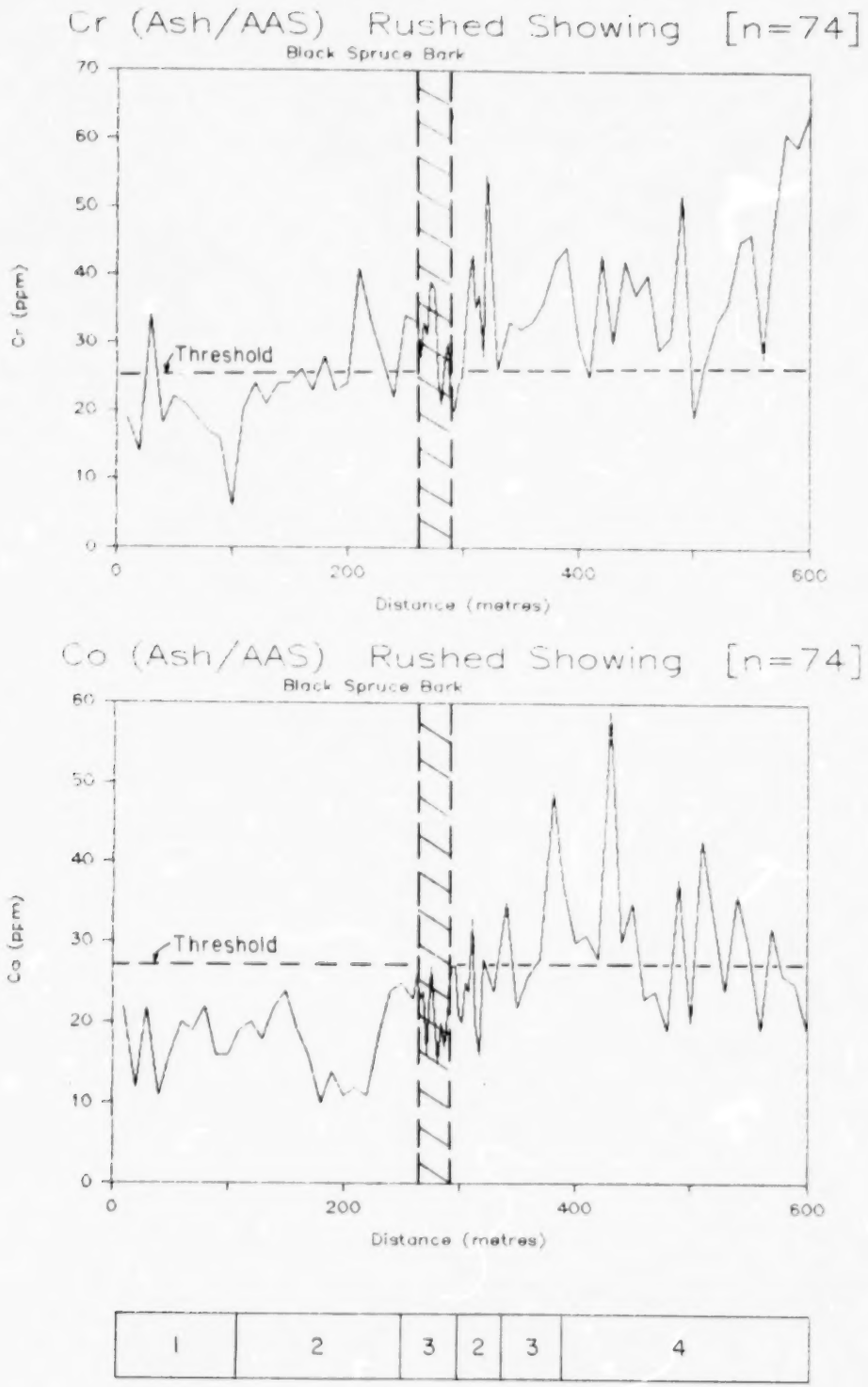
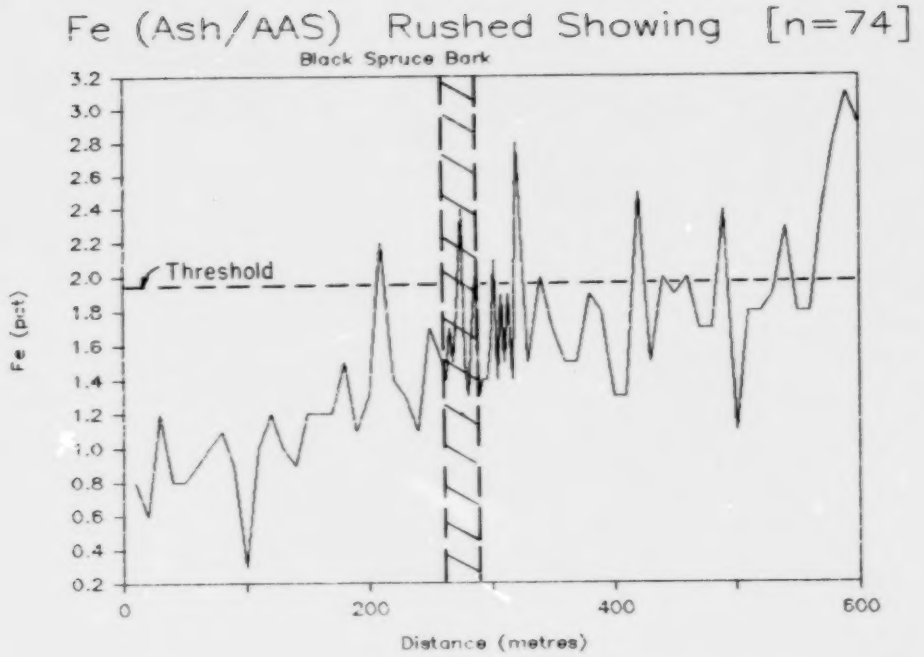
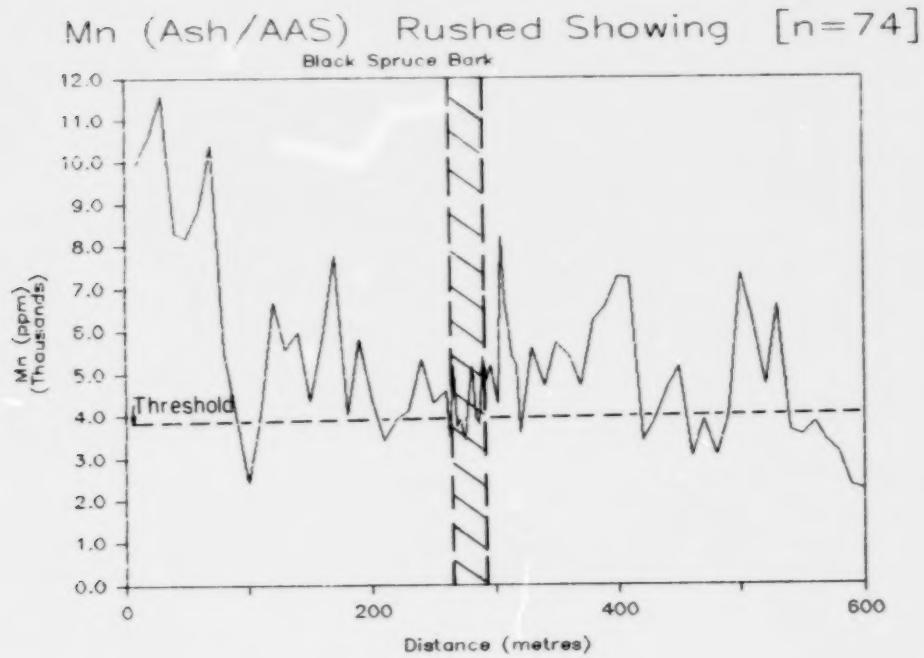


Figure 7: Cr and Co contents in ash of black spruce bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by vertical dashed lines. Legend for geological section as follows: 1-granite, 2-aluminous basalt, 3-clastic sedimentary rocks, 4-high Mg-Ni-Cr basalt (picrite).





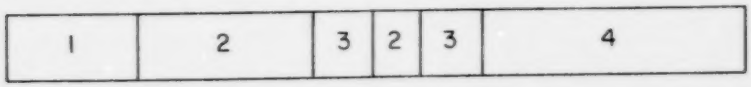


Figure 8: Fe and Mn contents in ash of black spruce bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by vertical dashed lines. Legend for geological section as follows: 1-granite, 2-aluminous basalt, 3-clastic sedimentary rocks, 4-high Mg-Ni-Cr basalt (picrite).

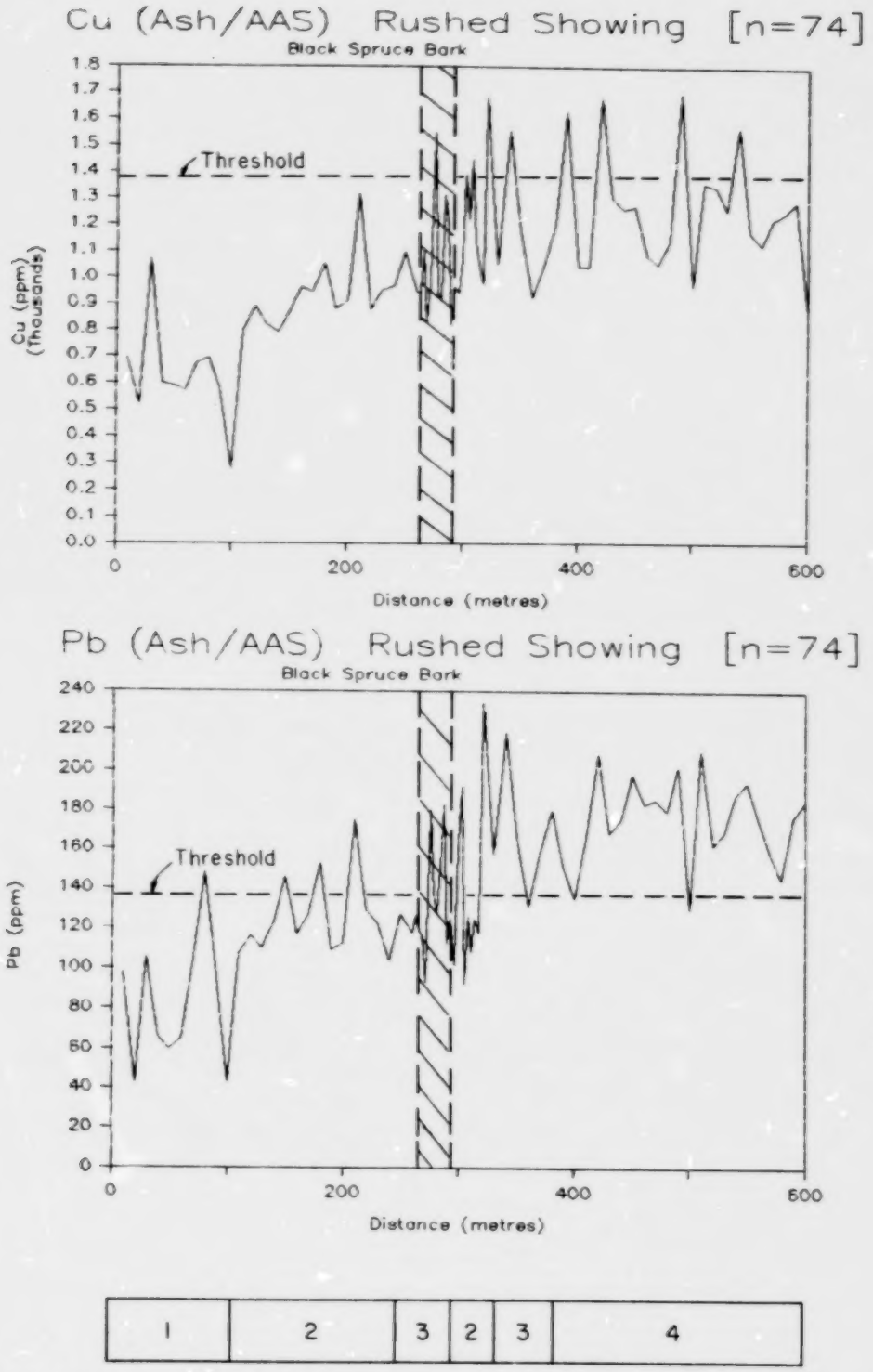


Figure 9: Cu and Pb contents in ash of black spruce bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by vertical dashed lines. Legend for geological section as follows: 1-granite, 2-aluminous basalt, 3-clastic sedimentary rocks, 4-high Mg-Ni-Cr basalt (picrite).

(700-1400 ppm versus 400-700 ppm), Cr (26-60 ppm versus 10-40 ppm) and Co (20-60 ppm versus 10-23 ppm) than samples collected over the clastic sedimentary rocks or the aluminous basalts. These elements are diagnostic of the MacLellan high Mg-Ni-Cr basalt (cf. Table 1, Fedikow, 1986a) and the recognition of anomalous contents of these elements in bark samples represents a potentially useful tool for property-scale exploration within the Agassiz Metallotect since the high Mg-Ni-Cr basalt represents a prime ingredient for MacLellan-type Au mineralization. The trends for Fe, Cu and Pb in bark samples between 260-600 m corresponds to the presence of Cu, Pb and Fe sulphides at the Rushed mineralization and in the underlying clastic sedimentary rocks and interlayered basalts.

Element ratios (Fig. 10-19) are indicative of distinct lithologic units in the substrate but are generally no more informative than results for single elements with the exception of Zn/Ba. The ratios Fe/Mn, Ni/Ba, Fe/Zn,Co/Zn and Ni/Zn are all successful in delineating the break between high Mg-Ni-Cr basalt or picrite (between 410 m and 600 m) and clastic sedimentary rocks and aluminous basalt units (between 0 and 410 m).

(iii) Drainage

The drainage effect on vegetation geochemical surveys (black spruce needles and twigs) for Au has been described previously in Fedikow (1985). The results of the present vegetation geochemical survey indicate that trace metal uptake and deposition in bark samples are affected by drainage. Both single element and element ratio profiles illustrate increased element mobility in wet, boggy ground versus drier, high ground along the sampling transect used for this study. Mn and Au are excellent indicators of the drainage effects on interpretation of the survey results. Apparent Mn and Au anomalies are obtained from between 0 and 100 m and 0 and 110 m, respectively, for these elements (Fig. 4 and 8); however, in this area of the transect the granitic bedrock lying beneath wet, organic-rich bog contains no known gold mineralization. Similar results for Mn and Zn have been obtained from black spruce surveys around the MacLellan Au-Ag deposit (cf. Fig. 14a and 15a, Fedikow, 1985). The effect of the Mn and Au contents in the samples collected

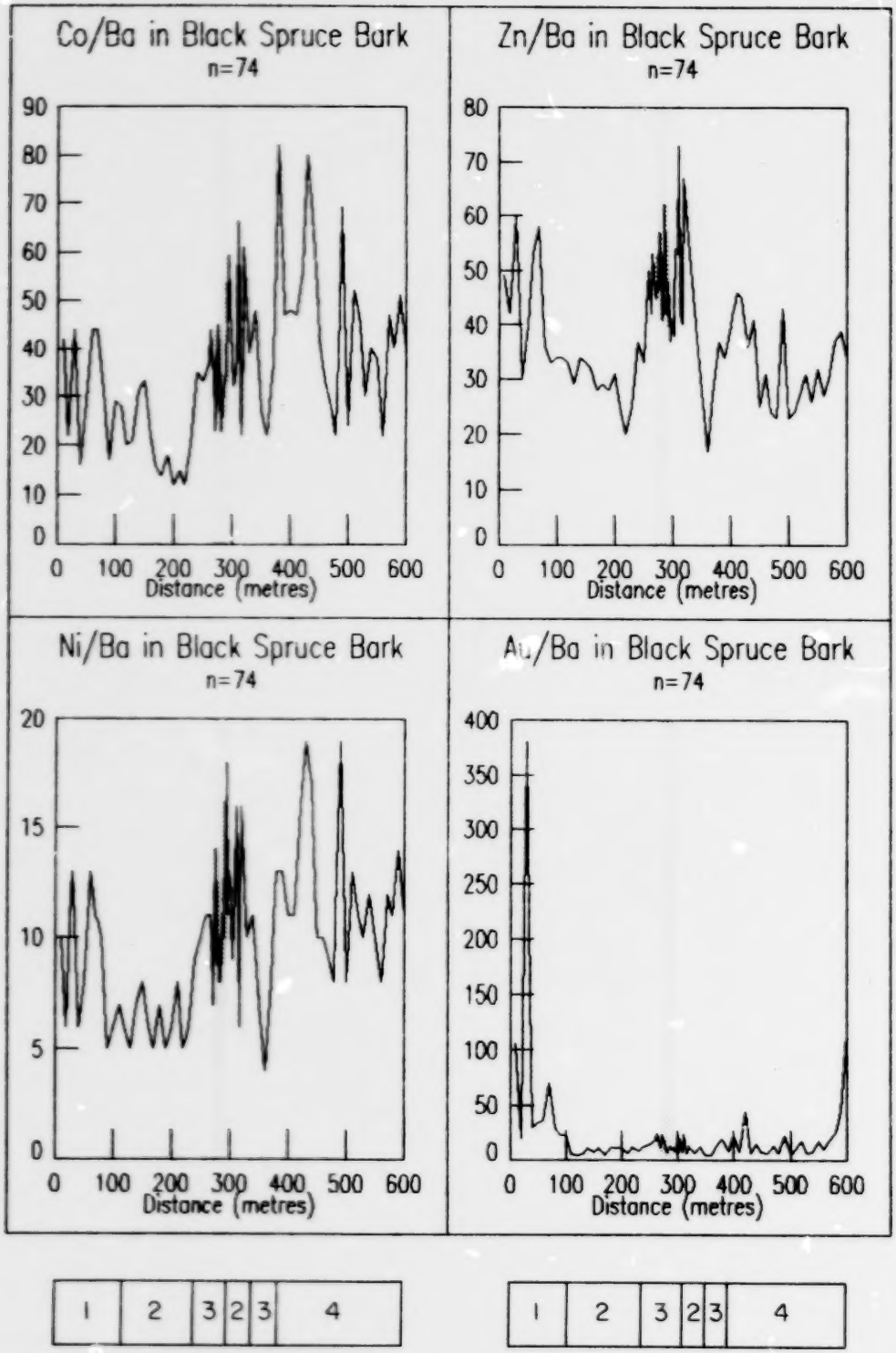


Figure 10: Element ratios in ash of bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

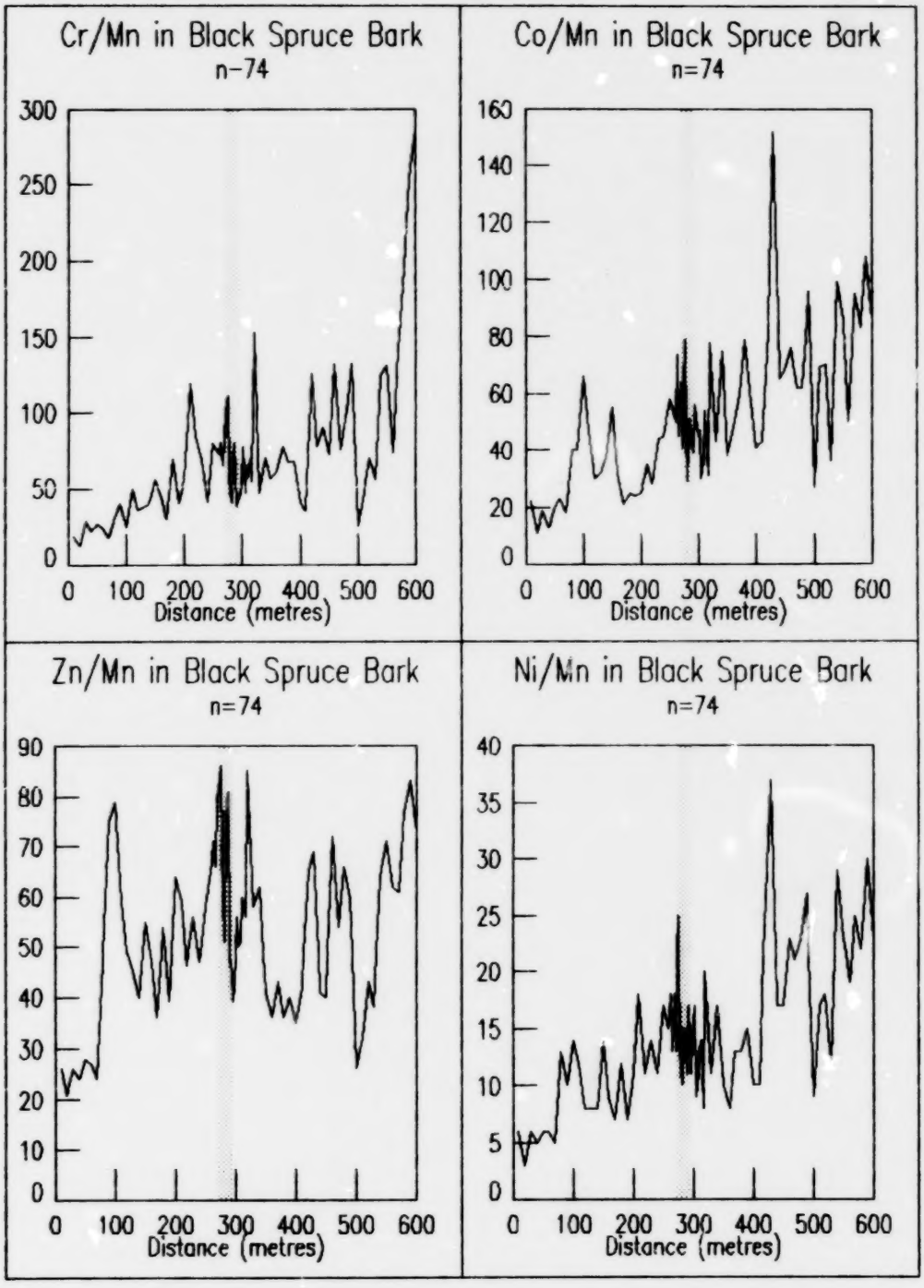


Figure 11: Element ratios in ash of bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

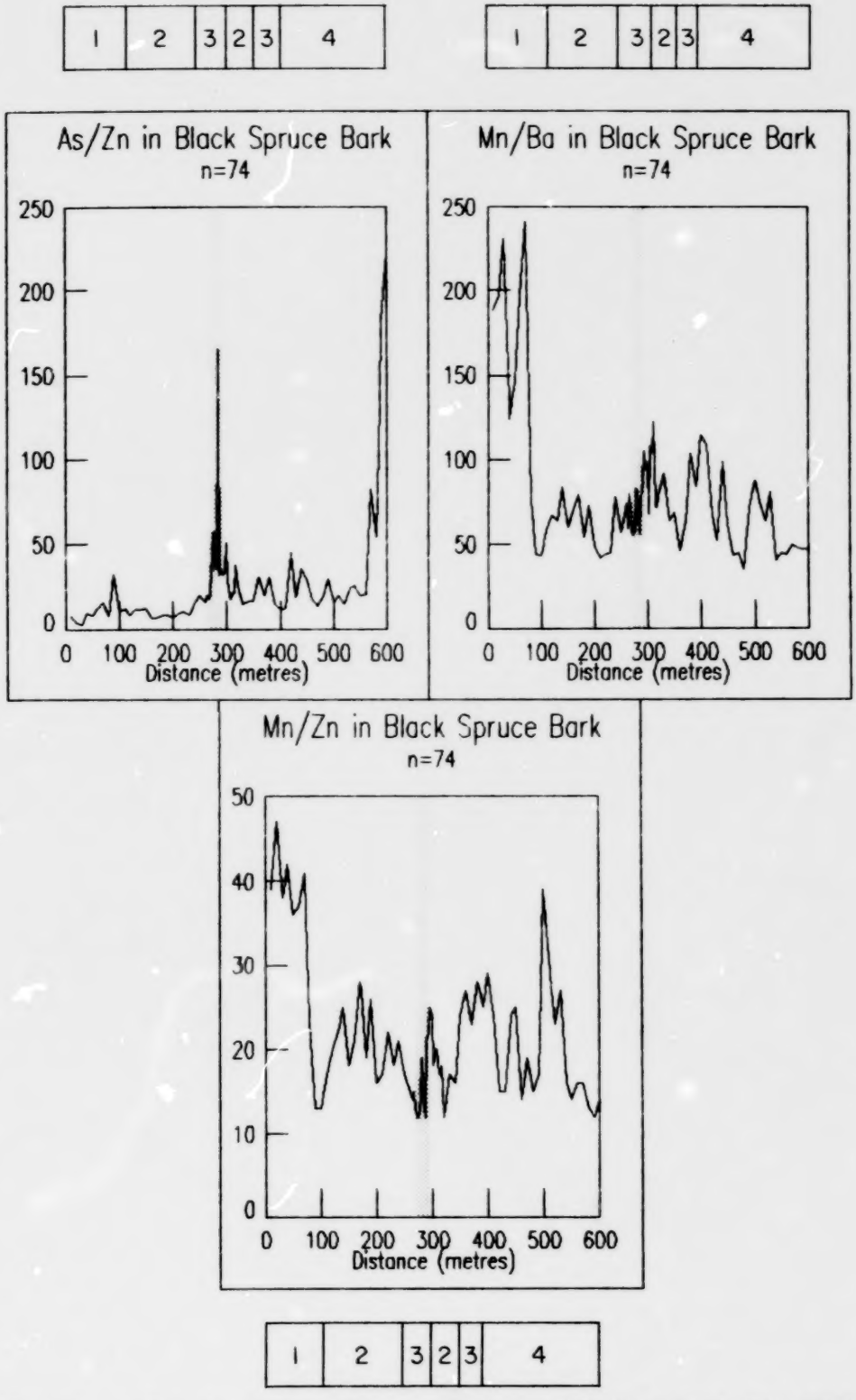


Figure 12: Element ratios in ash of bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

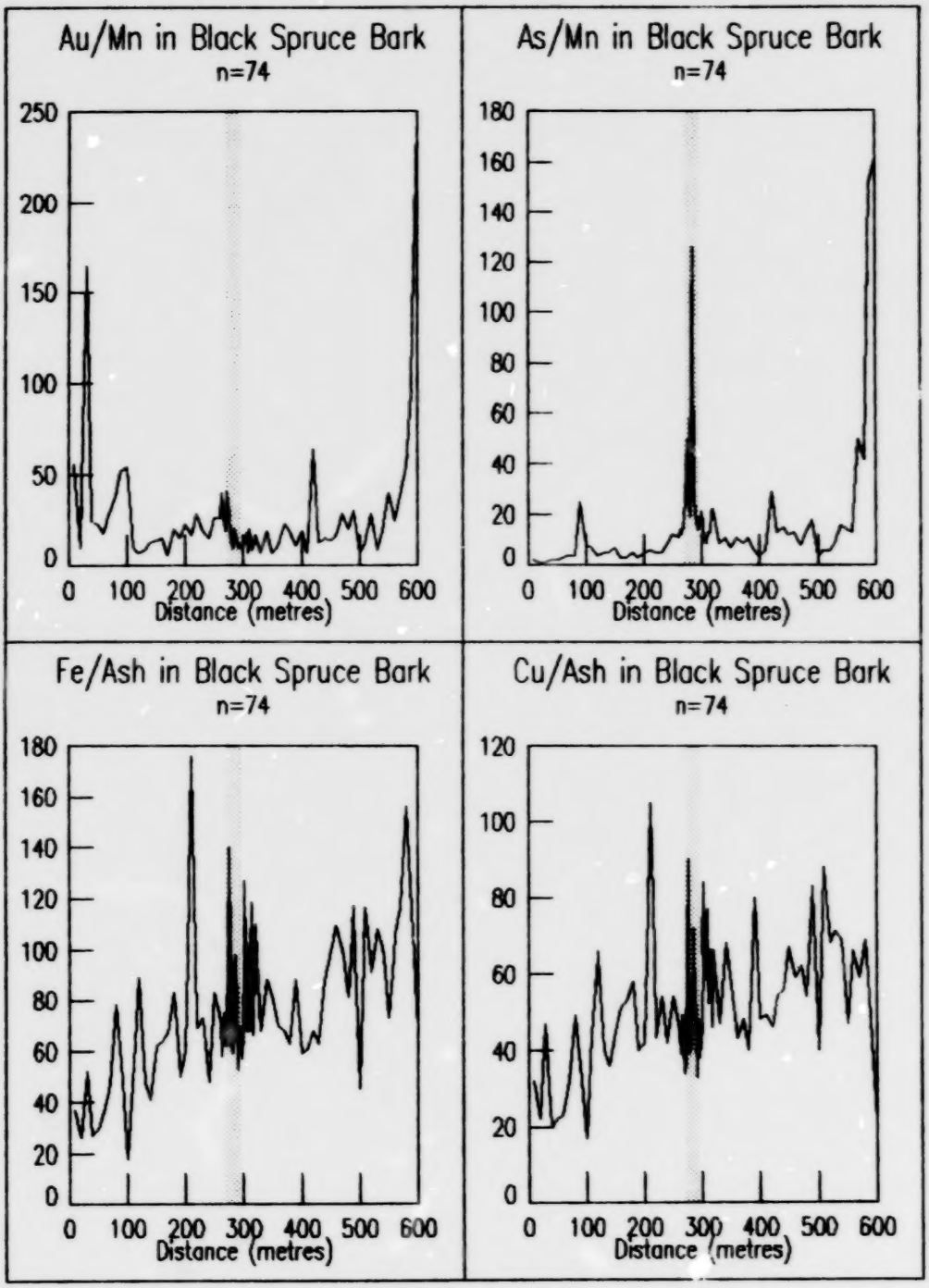


Figure 13: Element ratios in bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

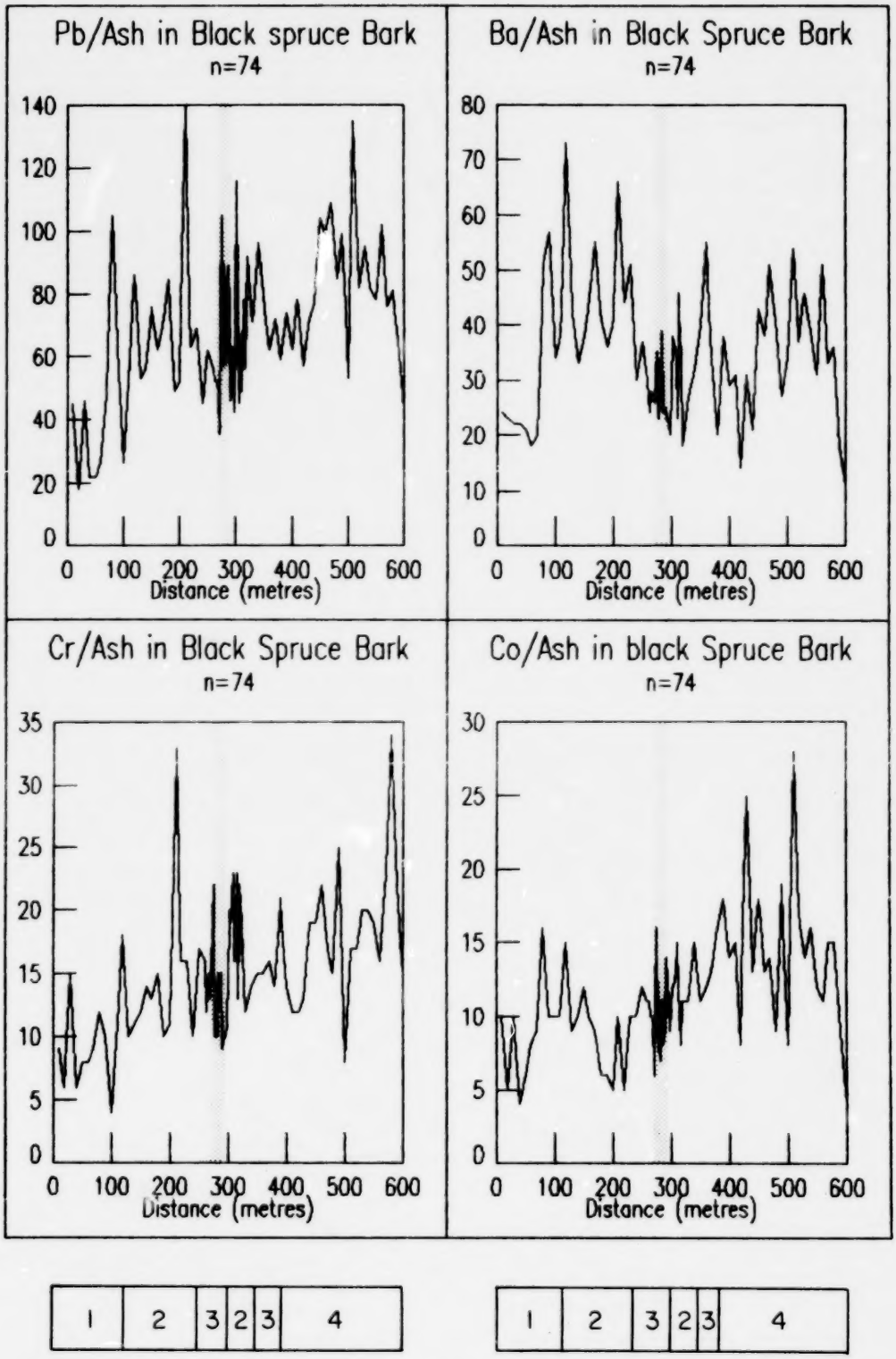


Figure 14: Element ratios in bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

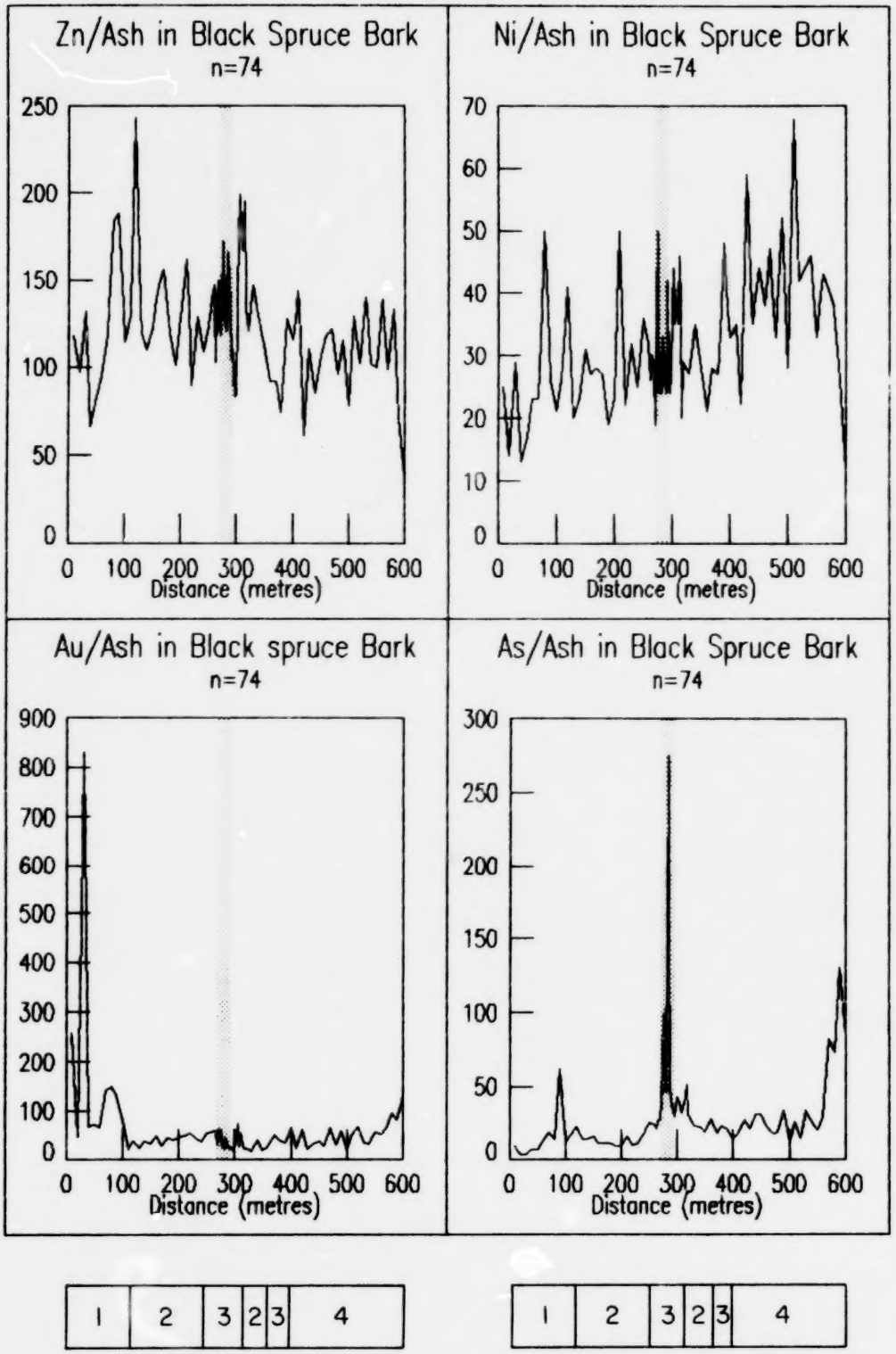


Figure 15: Element ratios in bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

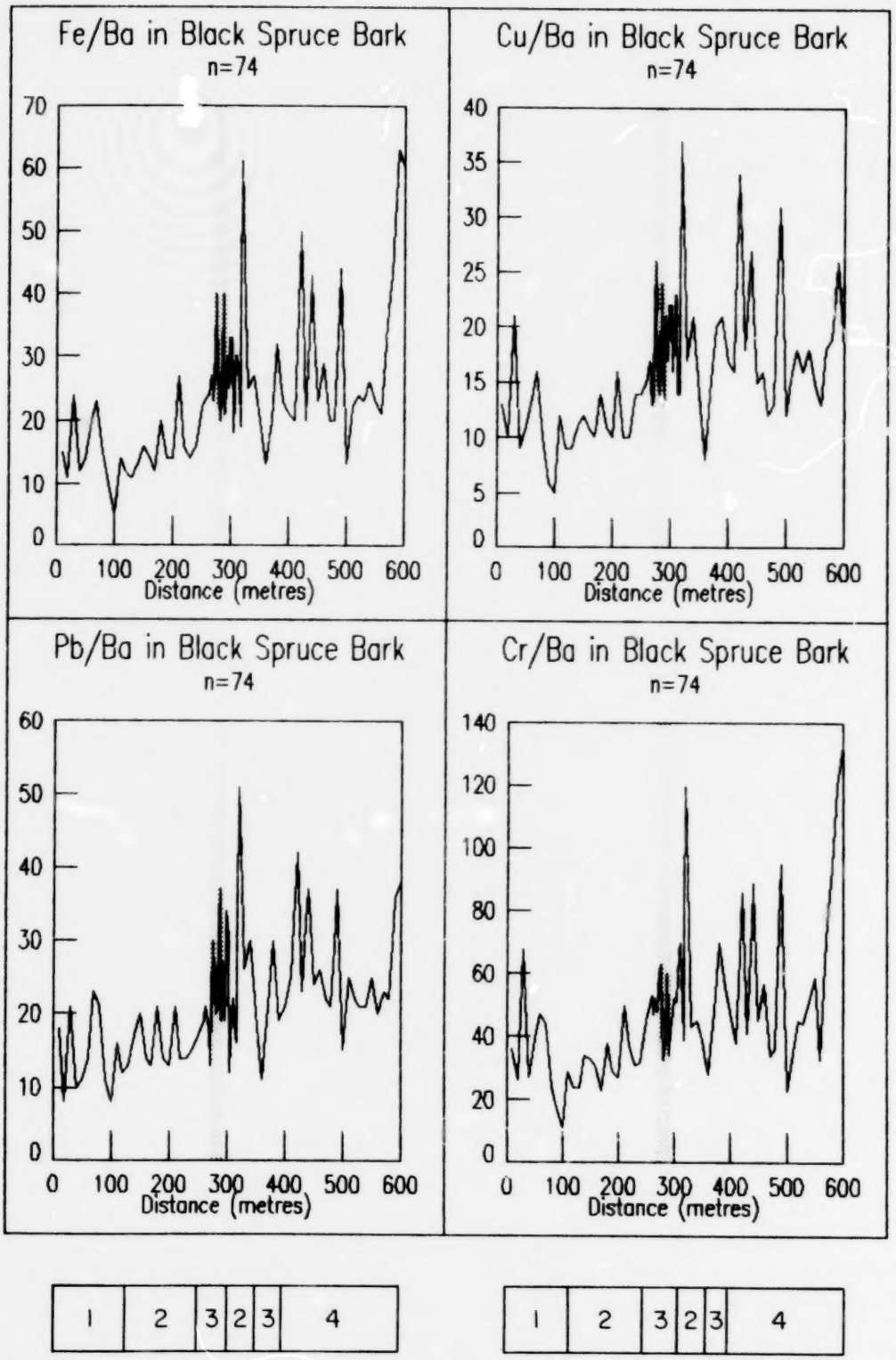


Figure 16: Element ratios in bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

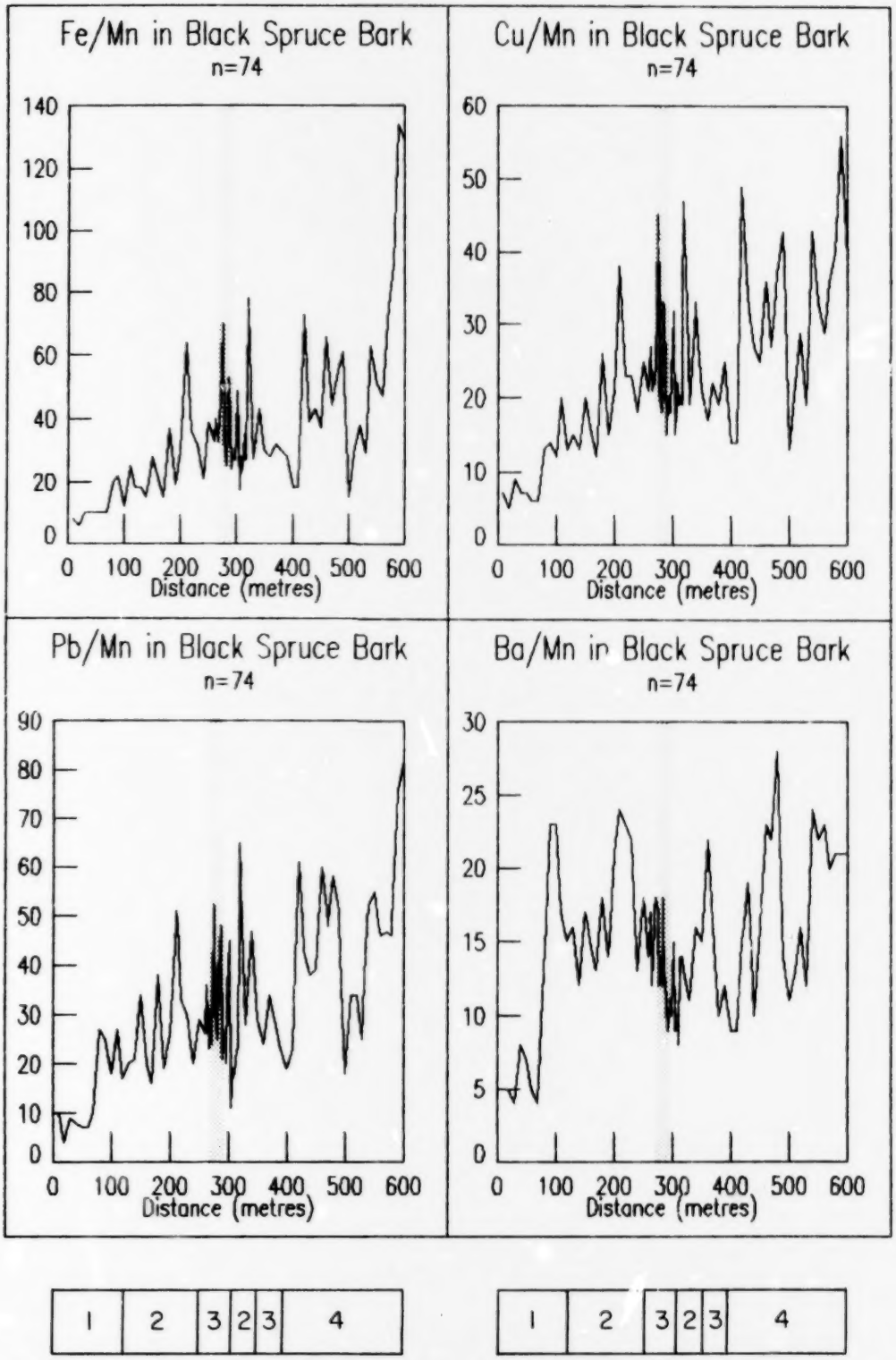


Figure 17: Element ratios in bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

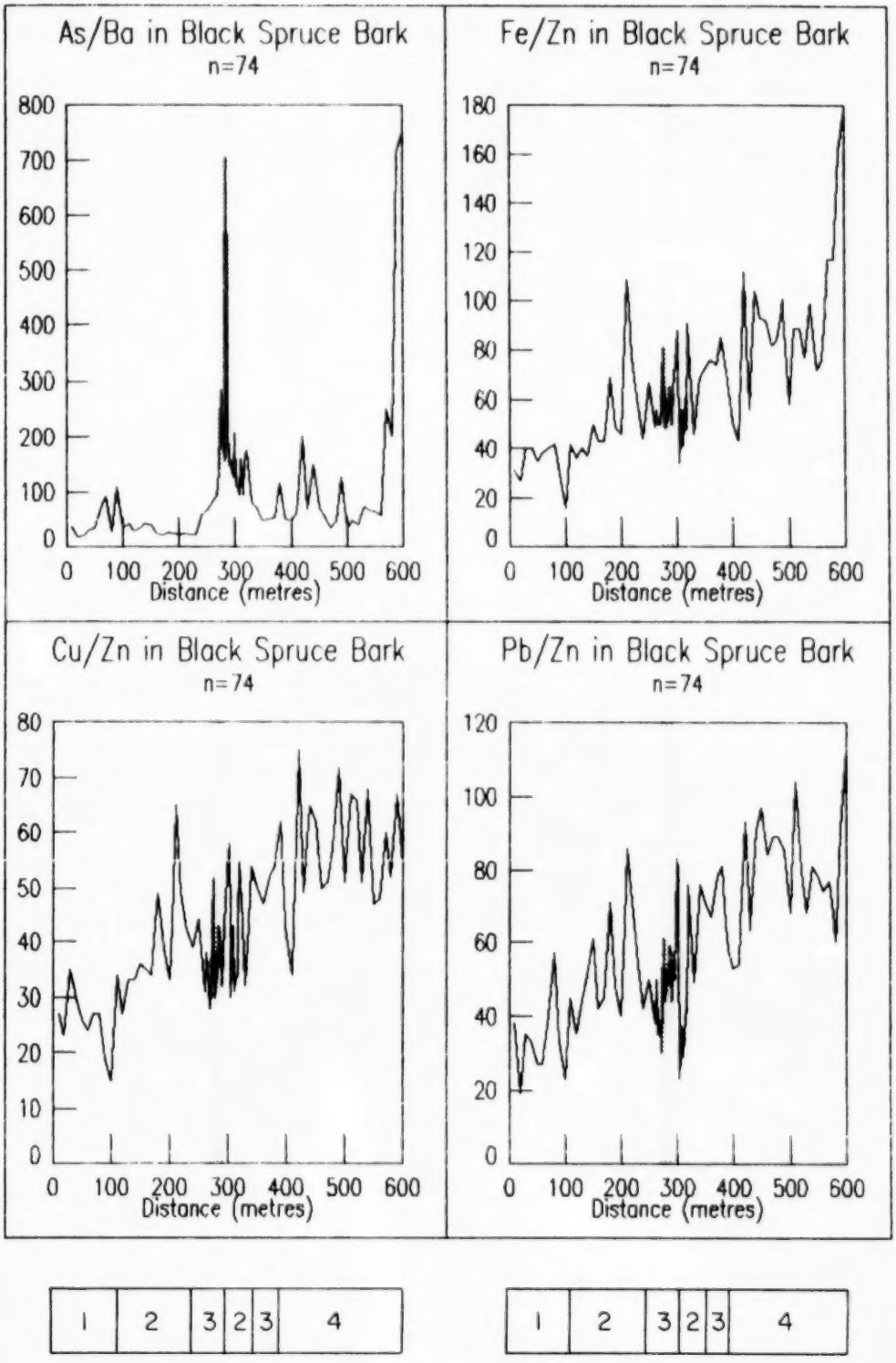


Figure 18: Element ratios in bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

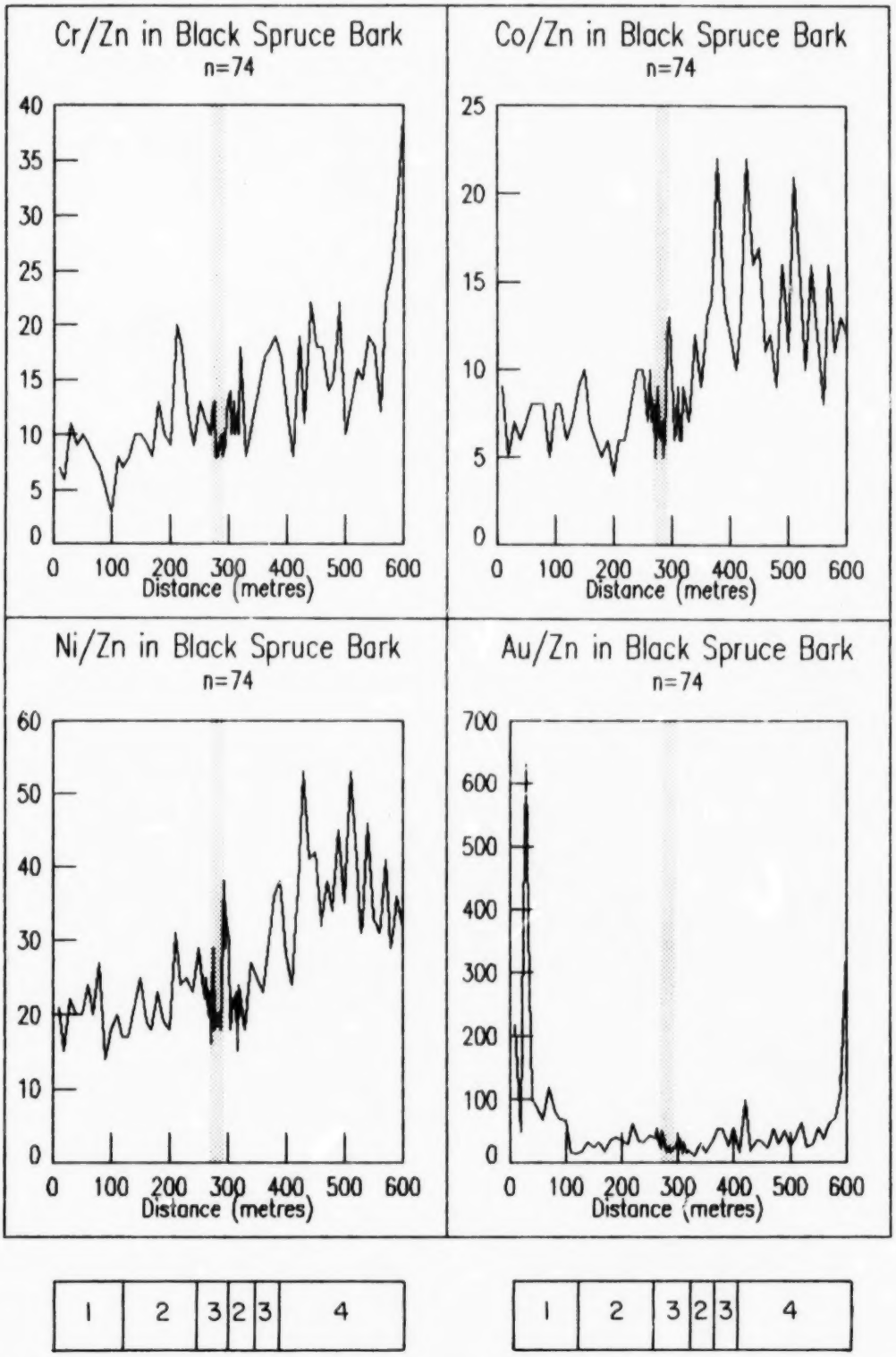


Figure 19: Element ratios in bark samples collected over the Rushed occurrence, Dot Lake. Mineralization indicated by the vertical stippled lines. Legend for geological section as in Figures 4 through 9.

over wet, boggy ground becomes apparent upon examination of Au/Ba (Fig. 10), Mn/Zn and Mn/Ba (Fig. 12), Au/Mn (Fig. 13), Au/Ash (Fig. 15) and Au/Zn (Fig. 19) ratios, all of which indicate increases in these elements over the bog. An excellent indicator of the gradually intensifying effects of drainage as the samples proceed from relatively well drained topography to the bog are the Zn/Ba results and to a lesser extent Co/Ba and Ni/Ba ratios depicted in Figure 10. From approximately 225 m to 0 m northwards along the sampling transect an increase in these ratios clearly delineates the poorly drained sampling areas.

DISCUSSION

The use of tree bark in exploration for base and precious metals and for determination of the nature of concealed bedrock has a fairly long history of application. Nielsen et al. (1973) utilized bark from *Eucalyptus lesouefii* to determine the geological nature of the substrate in a study area in Western Australia. Goff et al. (1985) utilized geochemical data from bark samples of the Monterey Pine *(Pinus radiata)* to test whether or not the bark provided useful information on the nature of the rocks in the substrate. Their study revealed that Cr, Ni and Na effectively delineated the nature of substrate (andesite and quartz "reefs"). Of these three elements Ni and Na gave the highest degree of correlation between bark and rock type.

This study demonstrates a successful application of black spruce bark geochemistry to the determination of bedrock in the vicinity of the Rushed occurrence within the Agassiz Metallotect. The study was also successful in providing evidence that dispersion phenomena related to the Rushed mineralization are present in the bark samples. The anomaly width, however, is such that a very narrow (3-5 m) sample spacing may be required to detect anomalous concentrations of trace metals. This observation places serious limitations on the method for detecting stratabound Au-base metal-iron sulphide mineralization in the Lynn Lake area since the method necessarily becomes more expensive per line kilometre (or mile) for property evaluation than many other exploration techniques (geophysical and geochemical). The technique does, however, hold promise for the detection of the high Mg-Ni-Cr

basalts that are associated with the MacLellan Au-Ag deposit. The ease of sample collection and the ubiquitous nature of the black spruce throughout the extent of the Agassiz Metallotect indicates a considerable potential for this method. In this study the Zn/Ba ratio apparently offered the only element combination useful for delineating the gold-bearing zone.

The correlation between mineralization and black spruce bark geochemistry appears to be highly dependent on the nature of the surficial deposits in the study area. Depth to bedrock is generally less than 1 m and the overlying material comprises sandy glacial till, peat bog, humus and forest litter. These conditions do not present a serious barrier to element migration and tapping of substrate by the shallow root system of black spruce. These surficial conditions, therefore, may be considered as "ideal" for application of vegetation geochemical surveys to problems of mineral exploration. The nature of surficial deposits within the Agassiz Metallotect is neither consistent, in terms of lateral or vertical extent, nor in the internal variability of any one area (i.e. till, permafrost peat, organic muds, sand, glaciolacustrine clay, humus, degree of water saturation). This variability along the Agassiz Metallotect may be explained by the location of the study area within the depositional basin of glacial Lake Agassiz. Little information has been presented in the literature regarding the variability within surficial deposits and how it affects vegetation geochemical responses to concealed, subcropping or outcropping mineralized zones. The vegetation geochemical responses to buried mineralized zones will almost certainly be affected by variable thicknesses of the individual components of the unconsolidated substrate. Accordingly, appropriate data must be acquired before vegetation geochemical techniques can be applied with confidence as a primary exploration tool. Evidence to substantiate the effect of natural barriers to element migration (which indirectly describes the subsequent effect upon element uptake by vegetation root systems) has been presented by Smee (1982). In that study the migration of cations and anions through glaciolacustrine sediments in response to natural galvanic forces generated by *massive sulphide* mineralization was examined. Laboratory experiments indicated that the radioisotope ^{65}Zn penetrated glaciolacustrine clay under the application of a direct current electrical potential similar in magnitude to a natural self-potential; however, movement of base-metal mineralization-

related cations through appreciable thicknesses of clay (20 m or more) was restricted to H^+ in the 8000 year old overburden section. These observations necessarily bring into question the application of vegetation geochemical surveys to gold exploration in terranes where the nature of the overburden is unknown. The driving force for element migration in Smee's study was massive sulphide mineralization. Most gold deposits are not of the massive sulphide type, rather they are related to quartz veins or disseminated (20%) sulphides. This brings into question how trace metals will be mobilized towards the shallow root systems of the vegetation types in the boreal forests of northern Canada. Natural galvanic self-potential forces related to quartz-vein type of disseminated sulphide-type gold mineralization are negligible in terms of their ability to mobilize trace metals with respect to the same galvanic forces attributed to massive sulphide deposits. Fluctuating groundwater levels and their interaction with glacially derived heavy metal dispersion fans may provide a partial answer. Although 20 m of glaciolacustrine clay is suggested by Smee as a near impenetrable barrier to element migration, unconsolidated overburden sequences with considerably less than 20 m of clay would also represent formidable migration barriers. For instance, 20 m of stratified overburden characterized by one or more glaciolacustrine clay layers interbedded with till, topped by permafrost peat bog, overlain by organic-rich muds that are invariably water saturated, is not an uncommon scenario in the depositional basin of glacial Lake Agassiz. For this reason an appreciation of the limitations of the vegetation geochemical method as they relate to the characteristics of the overburden is critical if unnecessary expenditures are to be avoided during a vegetation geochemical survey.

In the present study, as well as in previous vegetation studies around the MacLellan deposit, "false" vegetation geochemical anomalies with anomaly to background ratios (contrasts) equal to or greater than "real" geochemical anomalies have been observed for Au, Mn and Zn. These false anomaly contrasts are equivalent to those presented in the literature for real geochemical anomalies and indicate the serious problems that can arise when sampling vegetation and attempting to interpret results generated from well drained and poorly drained areas. Accordingly vegetation geochemical studies are probably best utilized as "back-up" or as "additional information" used to

confirm previous geological, geophysical, or other geochemical studies until such time as an understanding of the nature of the effects of unconsolidated substrate on vegetation geochemical responses in a study area is obtained.

CONCLUSIONS

The following conclusions are drawn from this bark geochemical study of the Rushed occurrence:

1. Trace element dispersion phenomena in ashed samples of black spruce bark can be used to delineate the high Mg-Ni-Cr basalts ("picrite") that host the MacLellan Au-Ag deposit and are associated with the Rushed occurrence. The technique is not applicable to delineation of trace element haloes related to Rushed type mineralization since the observed haloes are only marginally wider than the mineralized zone with the possible exception of ratioed trace element data. This requires expensive closely spaced sampling.

2. The analysis of Cr, Ni and Co in ash of black spruce bark effectively delineates the high Mg-Ni-Cr basalts in the study area and can be routinely determined using AAS.

3. Drainage effects are capable of producing false bark geochemical anomalies with anomaly to background contrasts equal to if not greater than real geochemical anomalies.

ACKNOWLEDGEMENTS

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APPENDIX I

Part I. ANALYTICAL SPECIFICATIONS

Part II. RAW ANALYTICAL DATA FOR BLACK SPRUCE BARK SAMPLES

Part I: Analytical Specifications

Atomic Absorption Analyses

For the determination of Cu, Pb, Zn, Cr, Ni, Co, Fe, Mn, Ba and ash the bark samples were dried, macerated to -20 mesh and then blended. A weight of 20 grams of sample was ashed at 450^{o}C and the ash dissolved with a 1:3 HCl-HNO_3 digestion. Analyses were conducted using atomic absorption spectrophotometry with lower limits of detection as follows: Cu, Zn, Co, Mn, Ba - 1 ppm; Pb, Ni, Cr - 2 ppm; Fe - 0.1%; Ash - 0.01%. Ash % was determined gravimetrically.

Neutron Activation Analyses

Au and As were determined in dry unwashed sample by neutron activation after first being dried, macerated to -20 mesh and then blended. A total of 8 grams of sample was then briquetted and shrink wrapped to avoid sample dehydration and concomitant variability in gold analyses. The lower limits of detection were: Au - 0.1 ppb and As - 0.1 ppm.

Part II. Raw Analytical Data for Black Spruce *(Picea mariana)*
Bark Samples - Rushed Occurrence

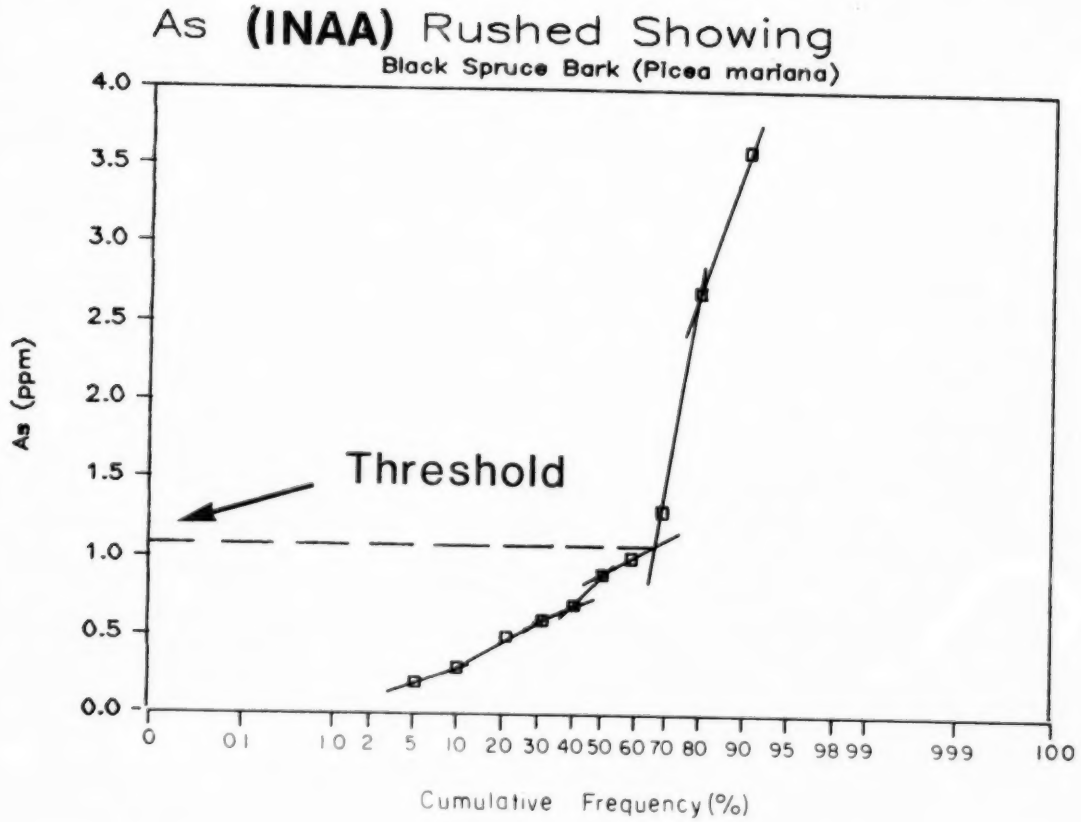
Sample Number	Dist. (m)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Cr (ppm)	Co (ppm)	Fe (%)	Mn (ppm)	Ba (ppm)	Au (ppb)	As (ppm)	Ash (%)
576 B38	10	695	98	2575	548	19	22	0.8	9950	53	5.6	0.2	2.19
575 B37	20	521	43	2258	336	14	12	0.6	10640	54	1.1	0.1	2.33
574 B36	30	1070	106	3022	674	34	22	1.2	11570	50	19.0	0.1	2.29
571 B33	40	602	66	1980	389	18	11	0.8	8330	67	2.0	0.2	2.98
570 B32	50	590	60	2256	462	22	16	0.8	8200	56	1.9	0.2	2.71
569 B31	60	574	65	2369	575	21	20	0.9	8880	45	1.6	0.3	2.49
568 B30	70	674	101	2502	490	19	19	1.0	10380	43	3.0	0.4	2.11
567 B29	80	696	148	2596	698	17	22	1.1	5530	72	2.1	0.2	1.41
566 B28	90	584	101	3031	418	16	16	0.9	4040	92	2.1	1.0	1.61
565 B27	100	281	43	1903	344	6	16	0.3	2420	56	1.3	0.2	1.65
564 B26	110	802	107	2359	479	20	19	1.0	4030	69	0.4	0.3	1.81
563 B25	120	891	116	3289	553	24	20	1.2	6670	99	0.5	0.3	1.35
562 B24	130	825	110	2490	422	21	18	1.0	5580	87	0.5	0.3	2.08
561 B23	140	795	123	2404	506	24	22	0.9	5960	71	0.8	0.3	2.18
560 B22	150	869	146	2383	592	24	24	1.2	4350	73	0.6	0.3	1.93
559 B21	160	962	117	2760	511	26	19	1.2	5850	85	0.9	0.2	1.88
558 B20	170	947	126	2806	508	23	16	1.2	7780	99	0.5	0.2	1.80
557 B19	180	1052	153	2166	492	28	10	1.5	4030	74	0.8	0.2	1.81
556 B18	190	883	109	2252	425	23	14	1.1	5810	80	0.9	0.2	2.22
555 B17	200	913	113	2797	501	24	11	1.3	4380	90	1.0	0.2	2.17
554 B16	210	1315	175	2024	628	41	12	2.2	3440	82	0.6	0.2	1.25
553 B15	220	882	129	1814	441	33	11	1.4	3920	90	1.1	0.2	2.04
552 B14	230	954	123	2288	569	28	18	1.3	4120	91	0.8	0.2	1.77
551 B13	240	966	104	2502	580	22	14	1.1	5330	68	0.8	0.4	2.29
550 B12	250	1099	127	2520	735	34	23	1.7	4310	76	1.1	0.5	2.04
549 B11	260	944	118	3077	670	33	23	1.5	4590	62	1.2	0.5	2.09
548 B10	263	948	126	2498	621	28	26	1.4	3498	59	1.4	0.5	2.43
547 B 9	266	1102	119	3396	682	33	23	1.7	5150	64	1.3	0.6	2.27
546 B 8	269	831	116	3004	679	31	24	1.5	3760	65	0.7	0.7	2.42
545 B 7	272	976	93	3152	513	39	16	1.8	3880	70	1.6	1.0	2.65
544 B 6	275	1549	180	2965	867	38	27	2.4	3430	60	1.0	1.7	1.72
543 B 5	278	938	137	3088	569	25	21	1.5	4460	54	0.7	1.1	2.40
542 B 4	281	911	128	2648	528	21	15	1.3	5160	64	0.5	1.0	2.19
541 B 3	284	1313	151	3022	603	27	20	1.7	3960	71	0.8	5.0	1.82
540 B 2	287	1199	183	3093	565	30	17	2.0	3800	50	0.6	1.0	2.05
539 B 1	290	821	113	2591	605	21	21	1.3	5380	61	0.6	0.9	2.47
538 B39	293	963	125	2195	840	20	27	1.4	4850	46	0.5	0.7	2.00
537 B40	296	942	102	2041	592	24	27	1.4	5180	55	0.5	0.7	2.45
536 B41	299	1075	163	1974	643	25	21	1.6	4680	48	0.7	1.0	2.35
535 B42	302	1390	192	2386	726	33	20	2.1	4280	63	0.5	0.7	1.66
534 B43	305	1223	92	4088	721	39	25	1.4	8240	76	1.5	0.8	2.05
533 B44	308	1449	126	3381	741	43	24	1.9	6670	64	0.5	0.6	1.89

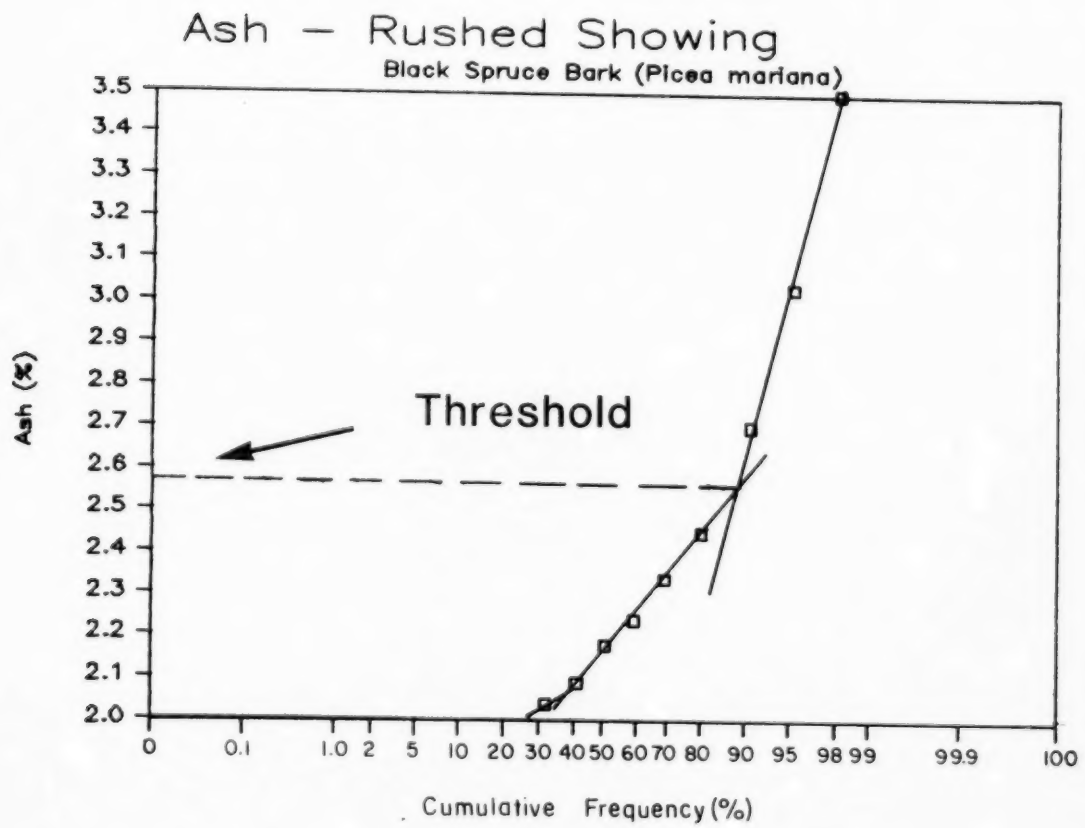
Continuation of Table - Part II.

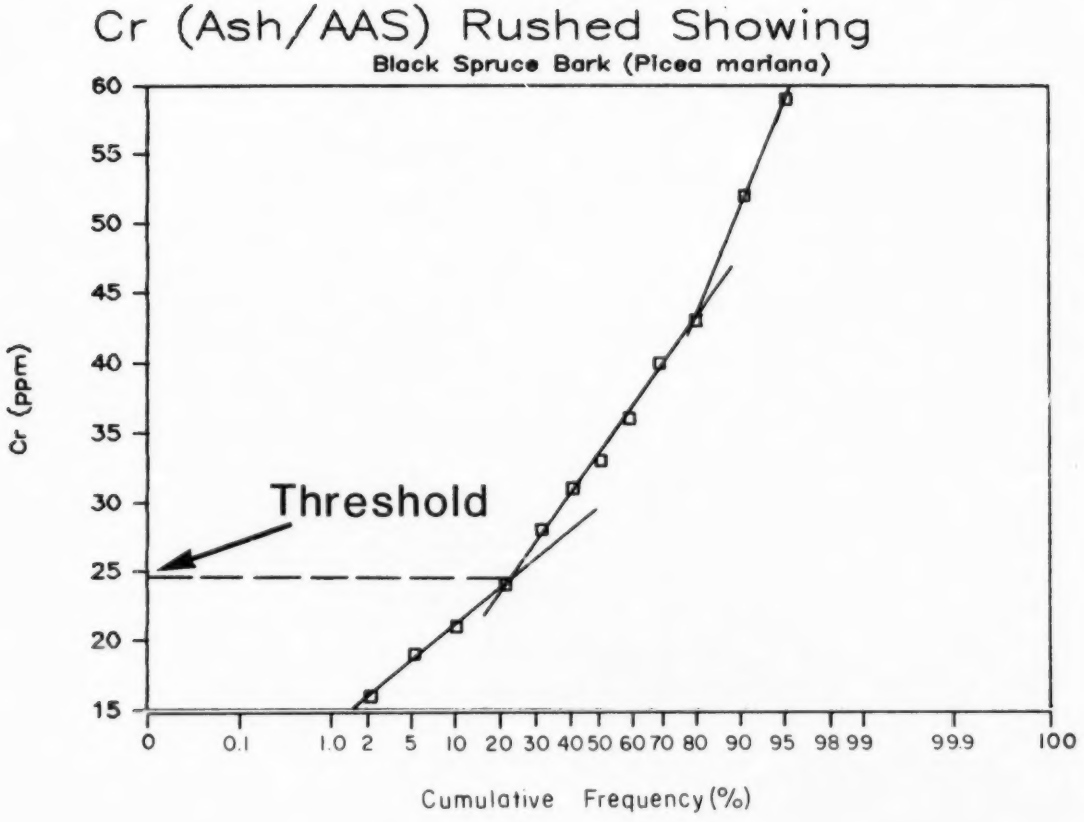
Sample Number	Dist. (m)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Cr (ppm)	Co (ppm)	Fe (%)	Mn (ppm)	Ba (ppm)	Au (ppb)	As (ppm)	Ash (%)
532 B45	311	1139	108	3668	775	35	33	1.5	6140	50	1.2	0.8	2.20
531 B46	314	1058	125	3137	737	37	20	1.9	5400	74	0.5	0.7	1.61
530 B47	317	977	118	2896	432	28	16	1.4	5170	72	0.5	1.1	2.11
529 B48	320	1685	234	3064	733	55	28	2.8	3600	46	0.6	0.8	2.54
528 B49	330	1053	158	3257	591	26	24	1.5	5590	61	0.4	0.5	2.22
527 B50	340	1556	219	2895	789	33	35	2.0	4690	73	0.9	0.5	2.28
526 B51	350	1178	166	2346	582	32	22	1.7	5720	83	0.4	0.4	2.08
525 B52	360	926	131	1967	454	33	26	1.5	5400	118	0.6	0.6	2.13
524 B53	370	1043	158	2023	617	36	28	1.5	4700	75	1.1	0.4	2.19
523 B54	380	1200	180	2236	803	42	49	1.9	6240	60	1.2	0.7	3.03
522 B55	390	1630	152	2634	992	44	37	1.8	6540	78	0.7	0.4	2.05
521 B56	400	1044	135	2534	715	30	30	1.3	7260	63	1.4	0.3	2.19
520 B57	410	1044	166	3052	734	25	31	1.3	7220	66	0.5	0.4	2.12
519 B58	420	1682	208	2234	820	43	28	2.5	3420	50	2.2	1.0	3.68
518 B59	430	1302	168	2663	1422	30	59	1.5	3880	74	0.5	0.5	2.40
517 B60	440	1260	175	1925	784	42	30	2.0	4650	47	0.7	0.7	2.26
516 B61	450	1272	198	2037	849	37	35	1.9	5130	83	0.7	0.6	1.91
515 B62	460	1088	183	2179	701	40	23	2.0	3040	70	0.5	0.4	1.84
514 B63	470	1054	185	2078	799	29	24	1.7	3880	86	1.1	0.3	1.70
513 B64	480	1144	179	2015	693	31	19	1.7	3073	87	0.6	0.4	2.10
512 B65	490	1699	202	2371	1067	52	38	2.4	3950	55	1.2	0.7	2.05
511 B66	500	972	130	1902	674	19	20	1.1	7350	84	0.5	0.3	2.45
510 B67	510	1358	210	2013	1061	27	43	1.8	6260	83	0.8	0.4	1.55
509 B68	520	1344	162	2025	831	33	33	1.8	4700	74	1.3	0.3	1.98
508 B69	530	1258	168	2472	773	36	24	1.9	6590	81	0.6	0.6	1.76
507 B70	540	1571	188	2316	1056	45	36	2.3	3640	89	0.7	0.6	2.28
506 B71	550	1174	194	2488	810	46	31	1.8	3510	78	1.4	0.5	2.48
505 B72	560	1126	174	2359	730	28	19	1.8	3820	86	0.9	0.5	1.70
504 B73	570	1224	158	2053	841	48	32	2.4	3380	68	1.3	1.7	2.07
503 B74	580	1242	145	2402	686	61	26	2.8	3130	65	1.7	1.3	1.79
502 B75	590	1288	176	1924	694	59	25	3.1	2320	49	2.2	3.5	2.70
501 B76	600	871	184	1624	524	64	19	2.9	2240	48	5.5	3.6	4.24

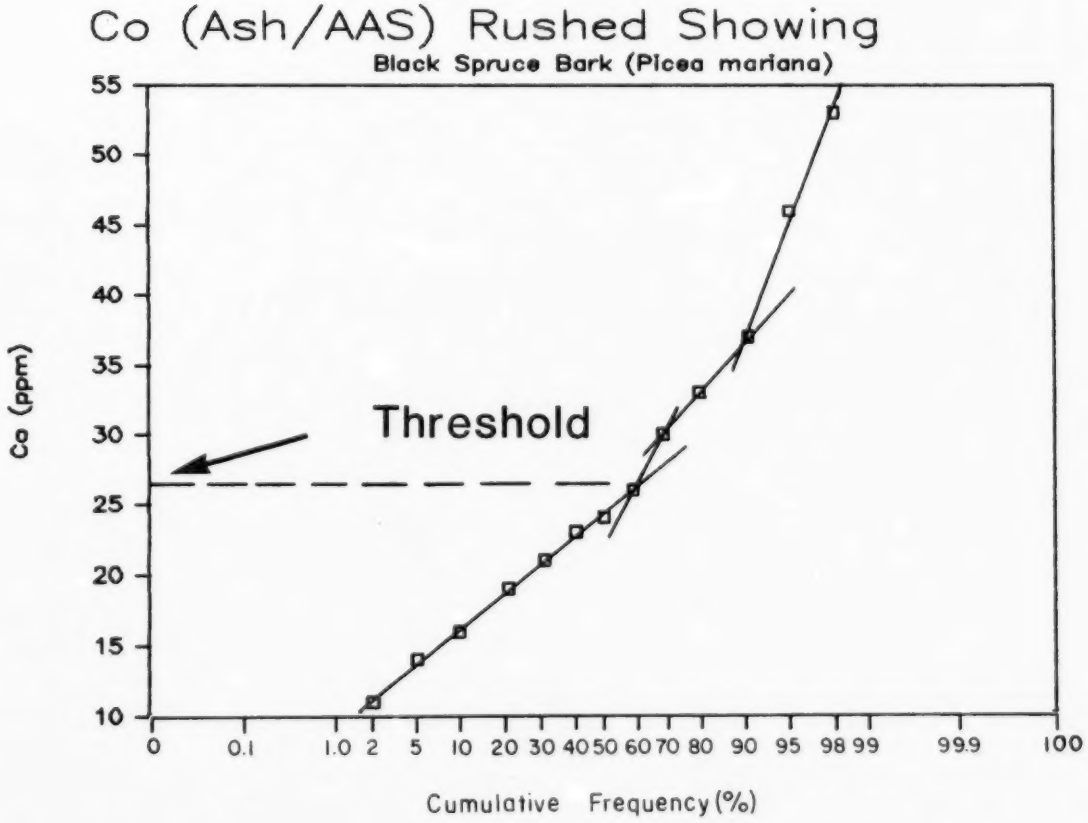
APPENDIX II

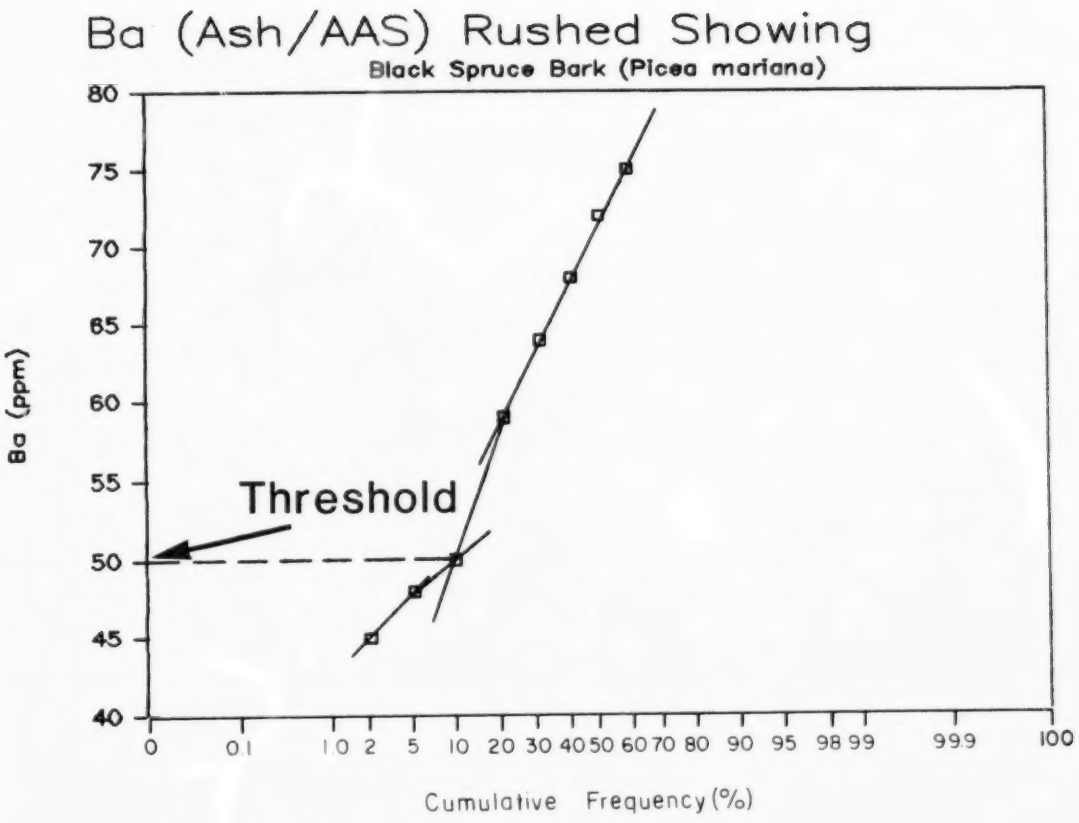
GRAPHICAL DETERMINATION OF THRESHOLD FOR
BLACK SPRUCE BARK ANALYSES

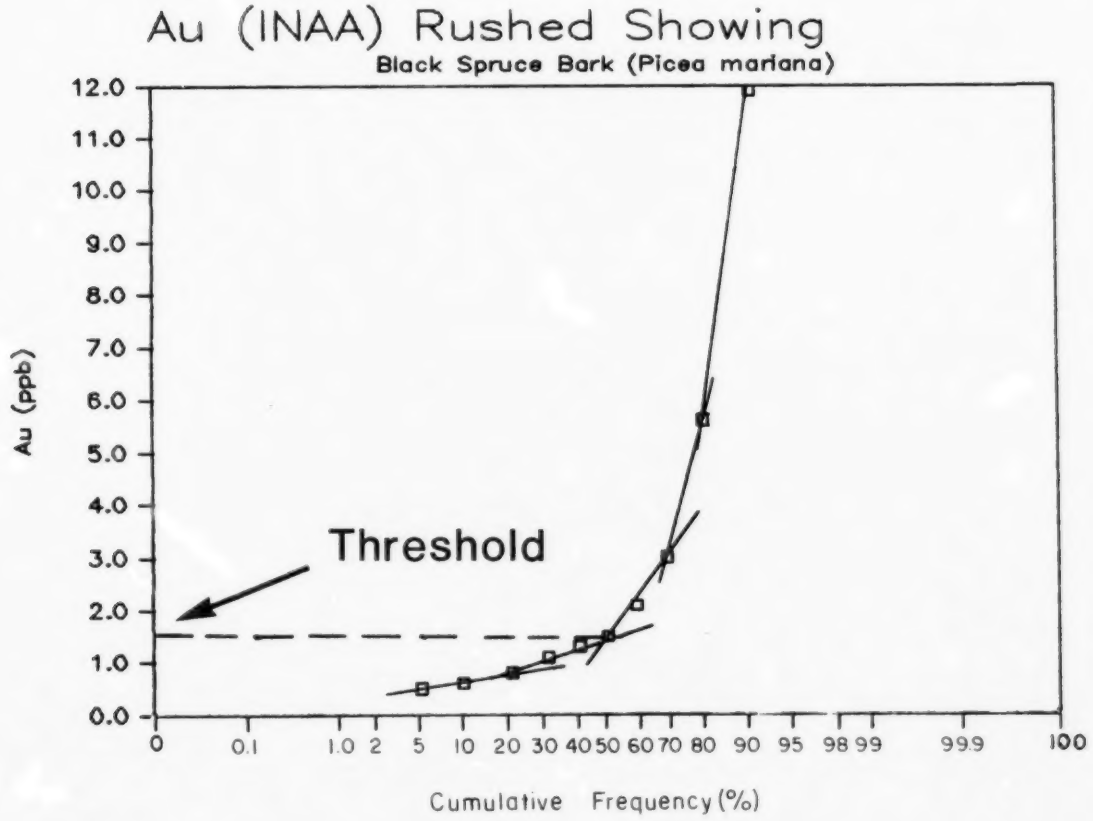

As (INAA) Rushed Showing
Black Spruce Bark (Picea mariana)
As (ppm)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)

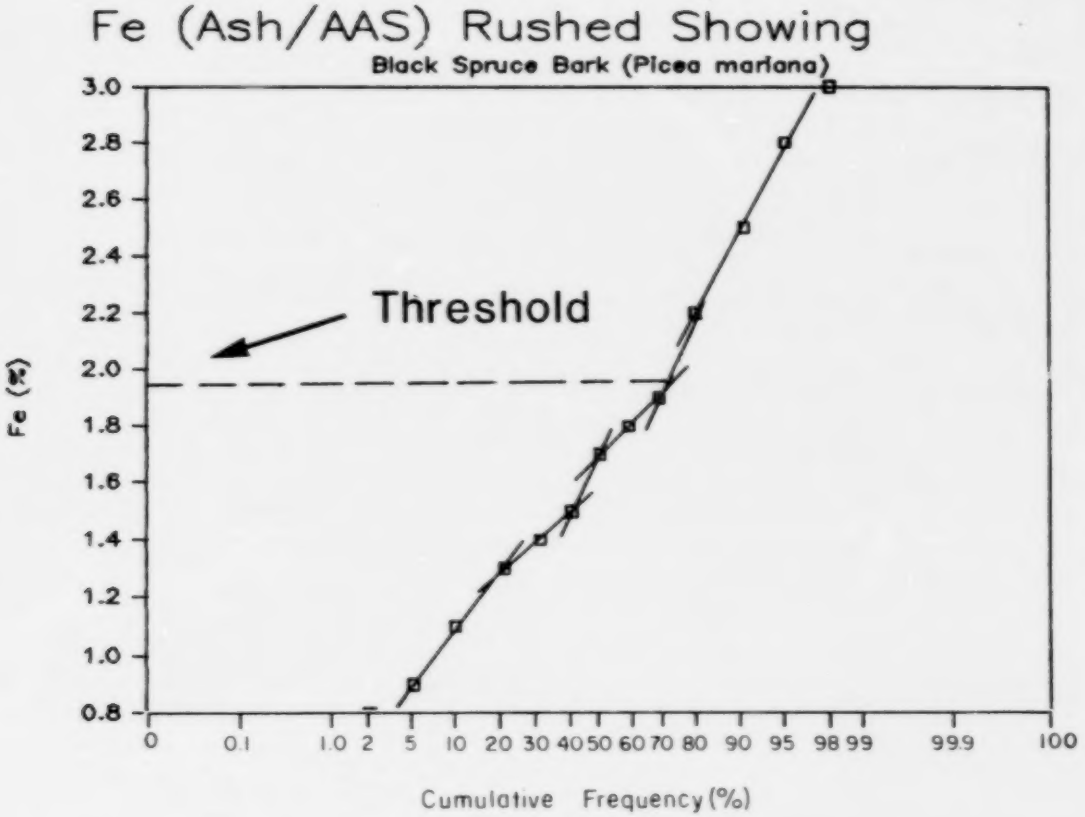

Ash – Rushed Showing
Black Spruce Bark (Picea mariana)
Ash (%)
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)

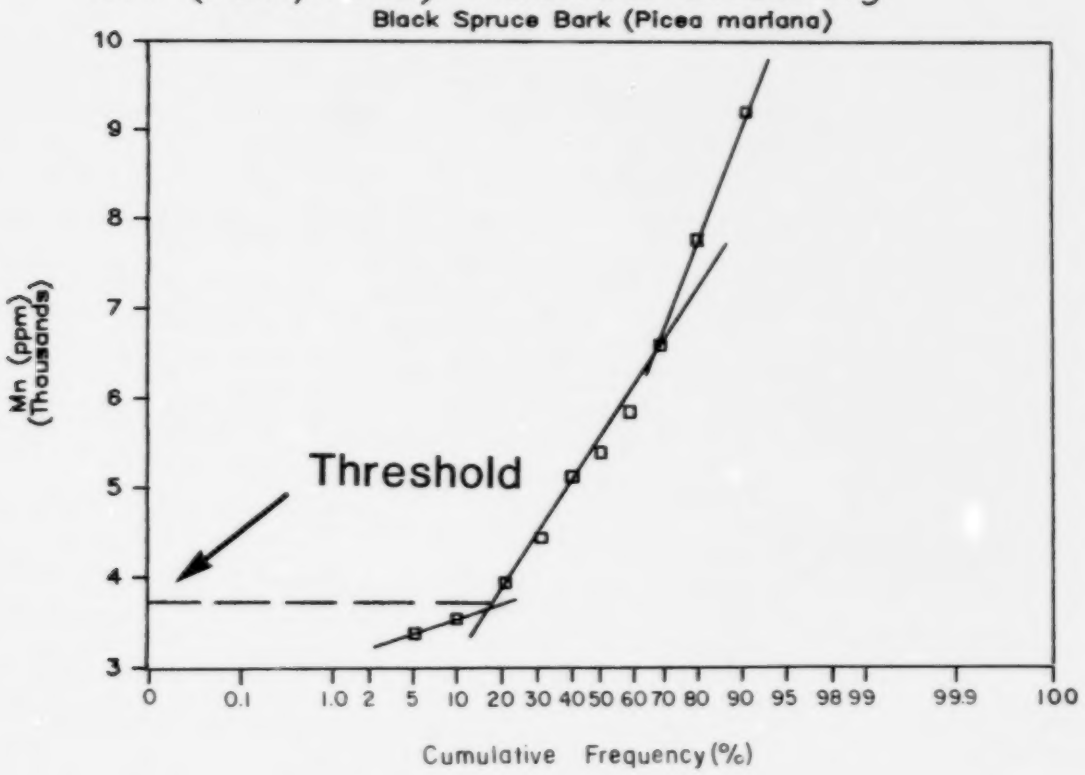

Cr (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Cr (ppm)
60
55
50
45
40
35
30
25
20
15
Threshold
0
0.1
1.0
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.9
100
Cumulative Frequency (%)

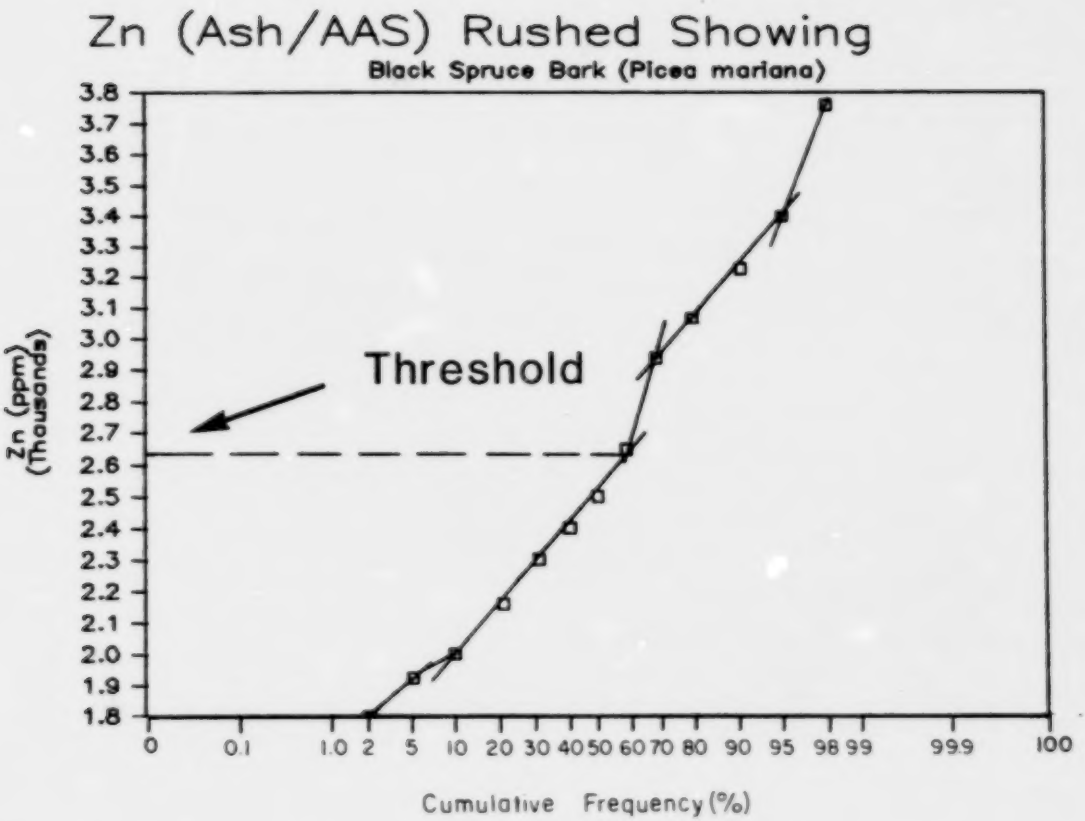

Co (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Co (ppm)
55
50
45
40
35
30
25
20
15
10
Threshold
0
0.1
1.0
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.9
100
Cumulative Frequency (%)

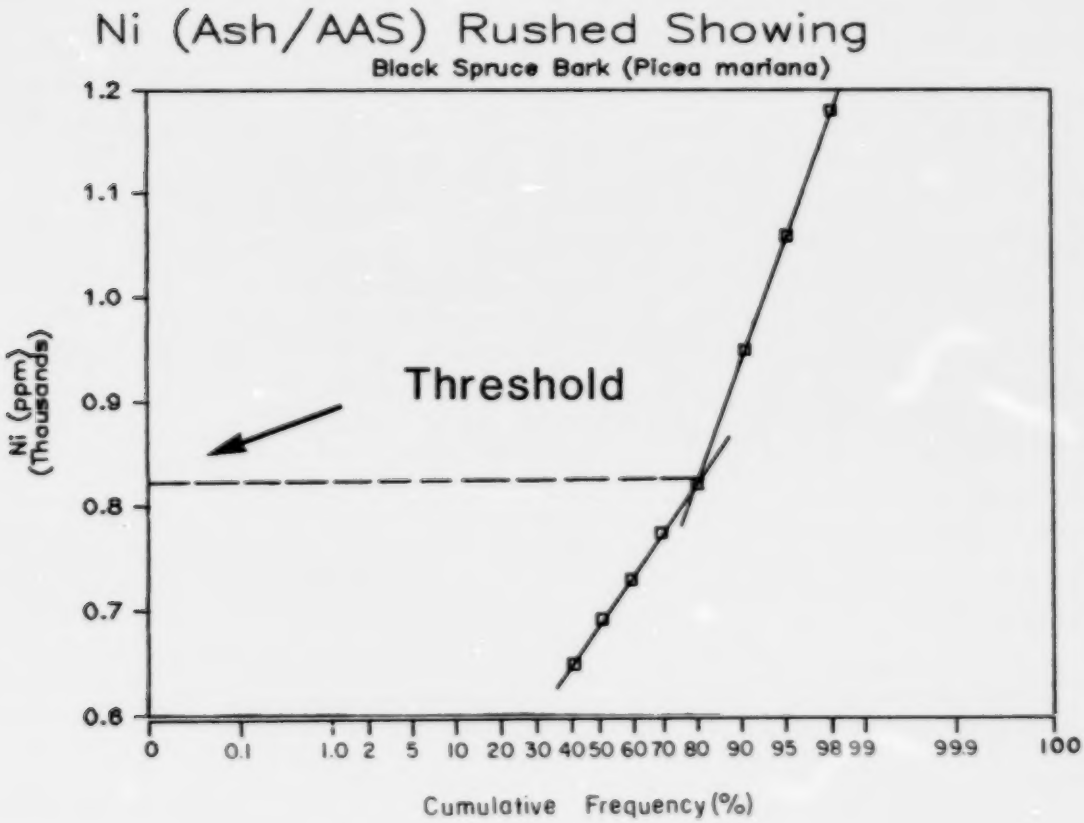

Ba (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Ba (ppm)
80
75
70
65
60
55
50
45
40
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)

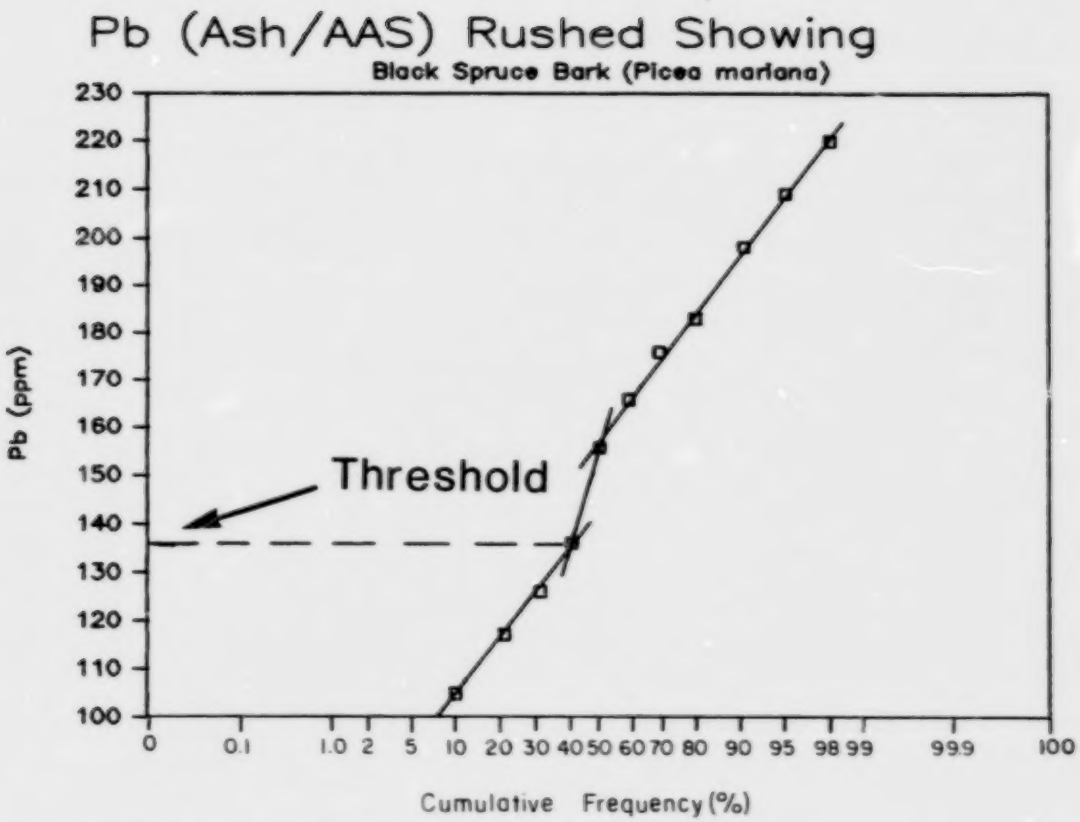

Au (INAA) Rushed Showing
Black Spruce Bark (Picea mariana)
Au (ppb)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)

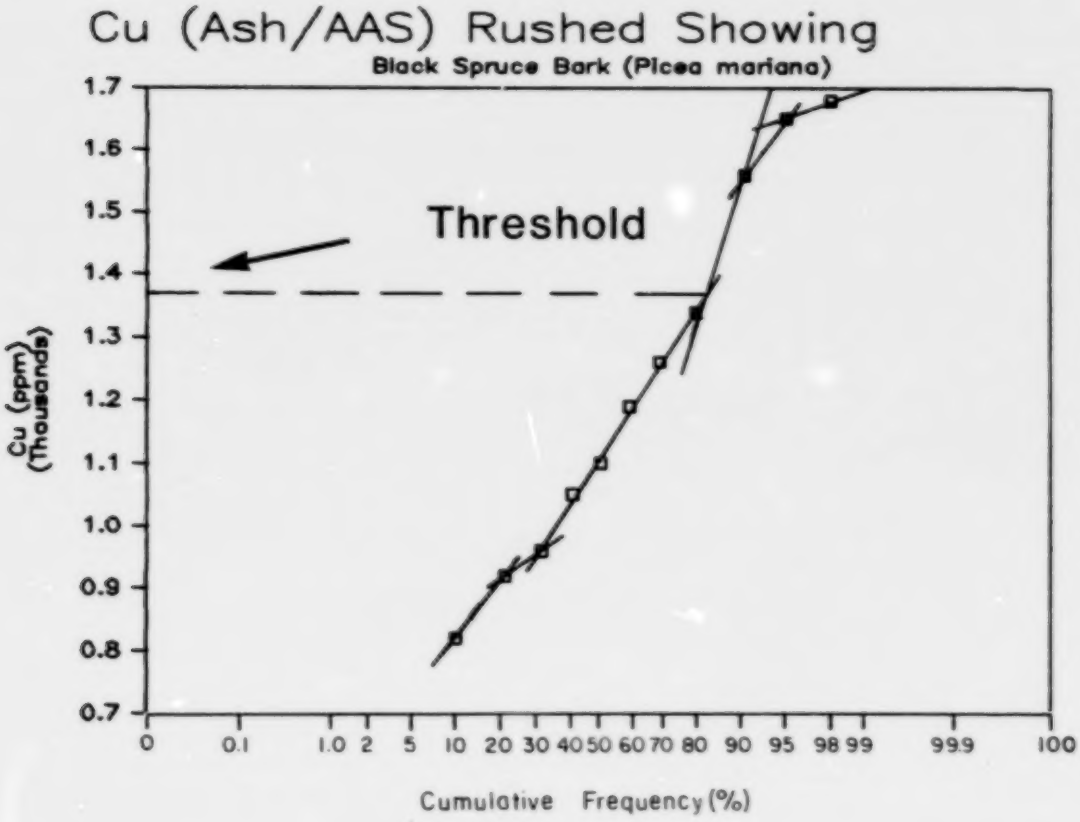

Fe (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Threshold
Fe (%)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)


Mn (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Threshold
Mn (ppm) (Thousands)
10
9
8
7
6
5
4
3
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)


Zn (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Zn (ppm) (Thousands)
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)


Ni (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Ni (ppm) (Thousands)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)

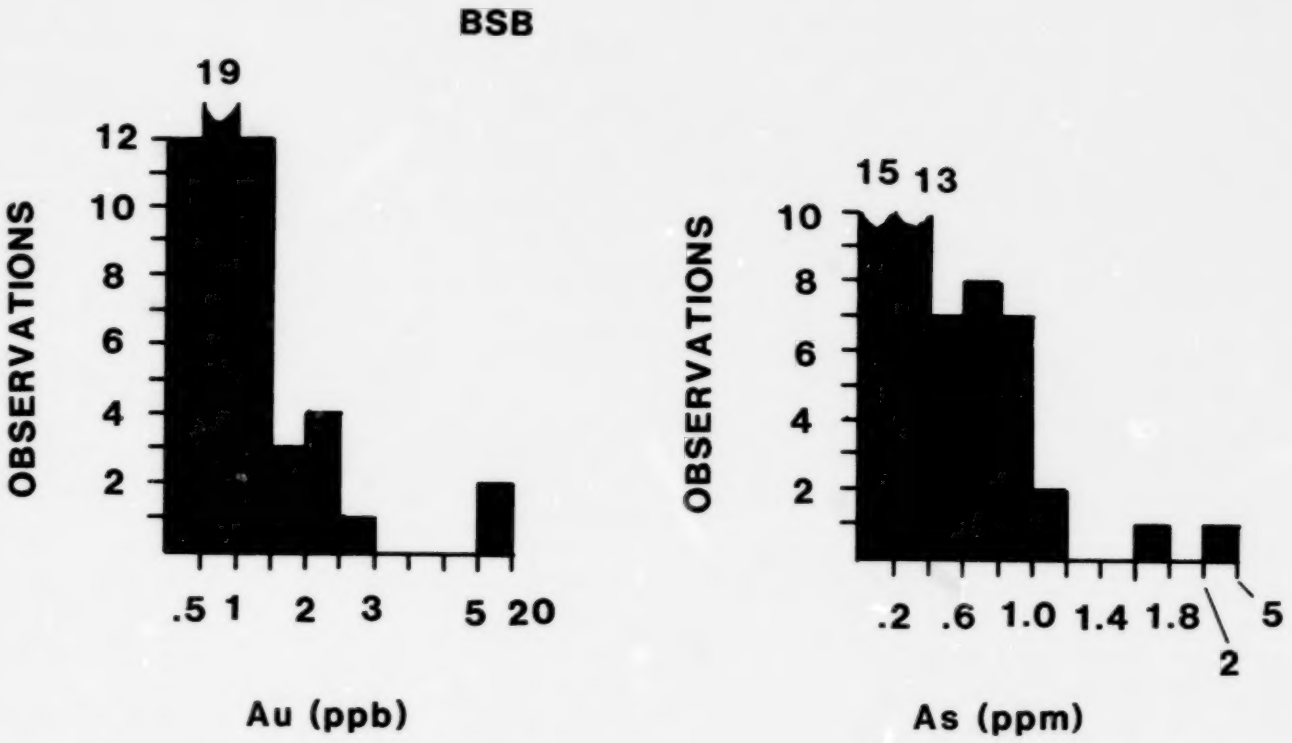

Pb (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Pb (ppm)
230
220
210
200
190
180
170
160
150
140
130
120
110
100
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)


Cu (Ash/AAS) Rushed Showing
Black Spruce Bark (Picea mariana)
Cu (ppm) (Thousands)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
Threshold
0 0.1 1.0 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 100
Cumulative Frequency (%)

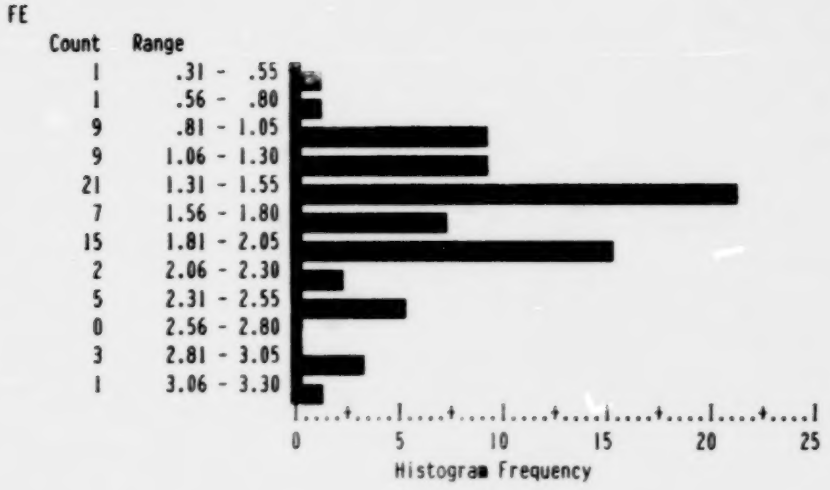
APPENDIX III

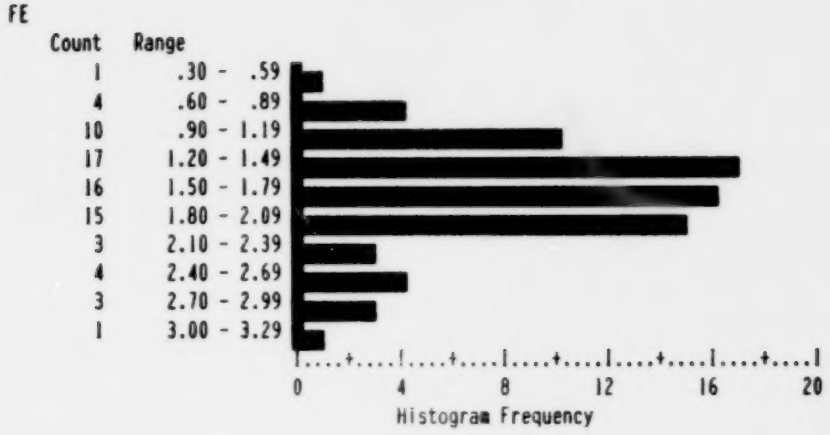
HISTOGRAMS

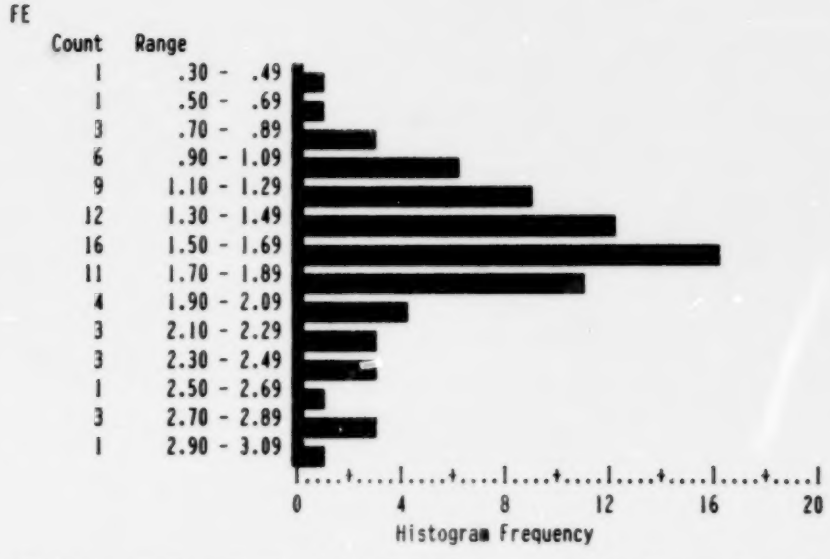
BLACK SPRUCE *(Picea mariana)* BARK



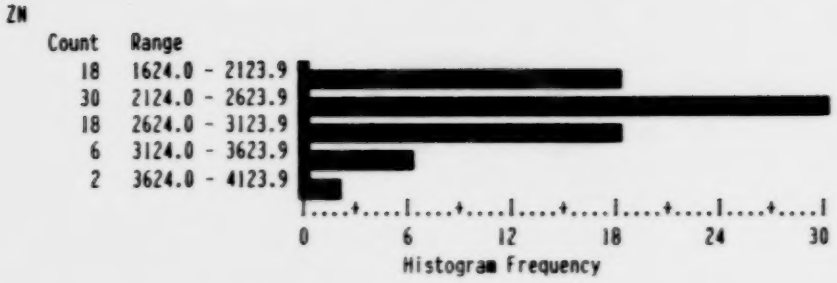
Histograms for Au and As in black spruce bark. Analysis based on INAA of dry, unashed sample.

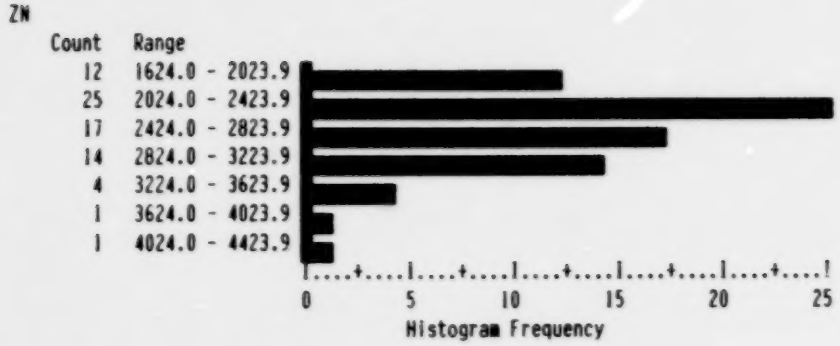


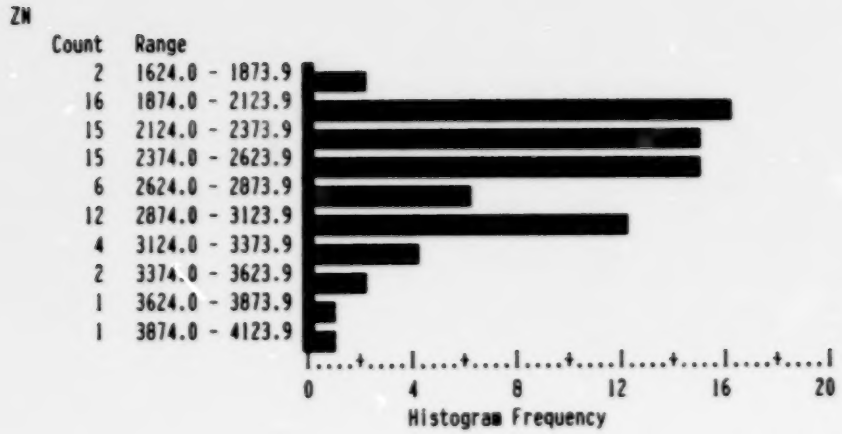




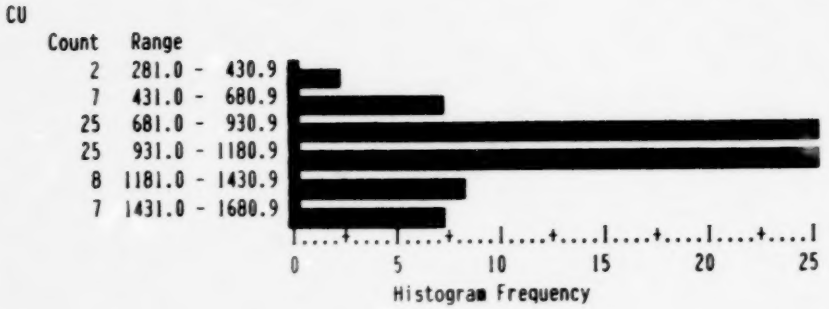
Histograms for Fe in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.

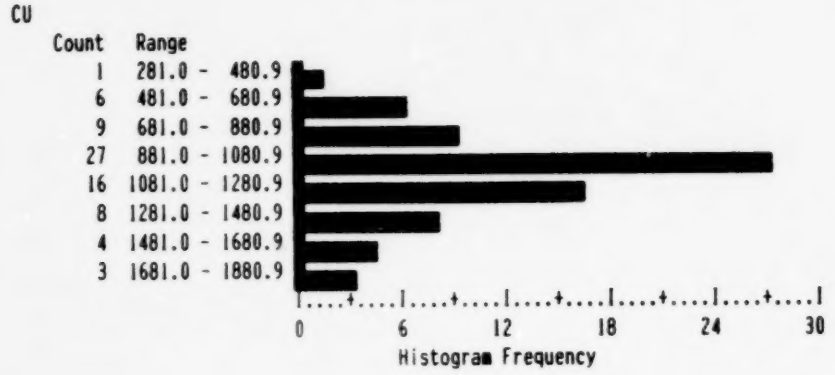


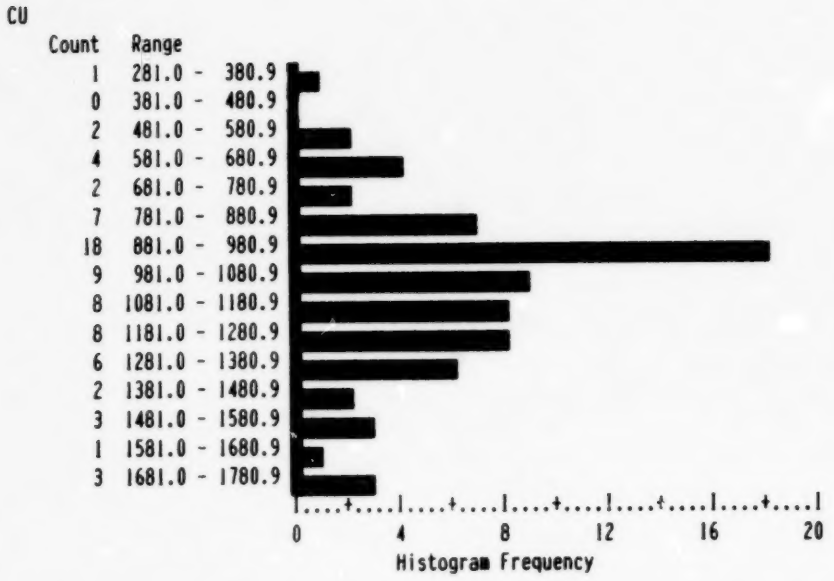




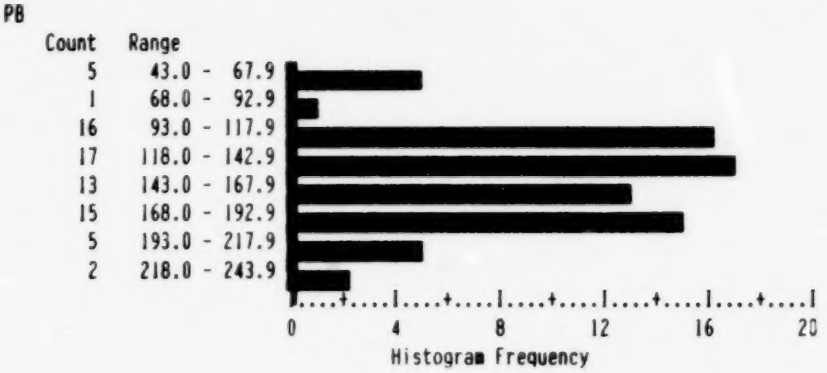
Histograms for Zn in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.

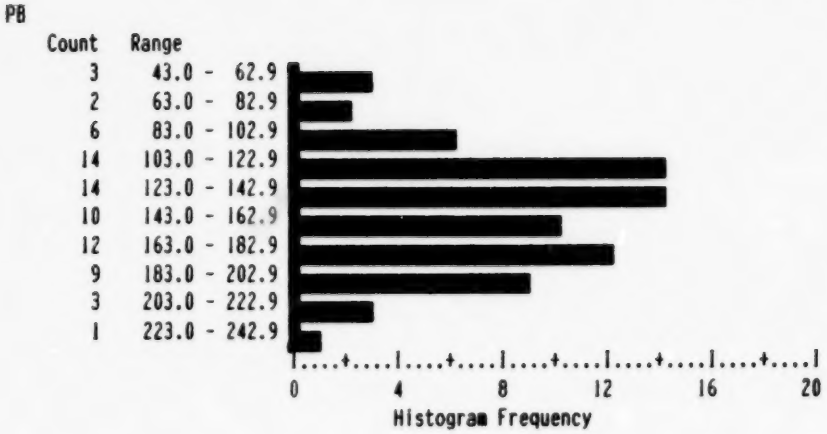




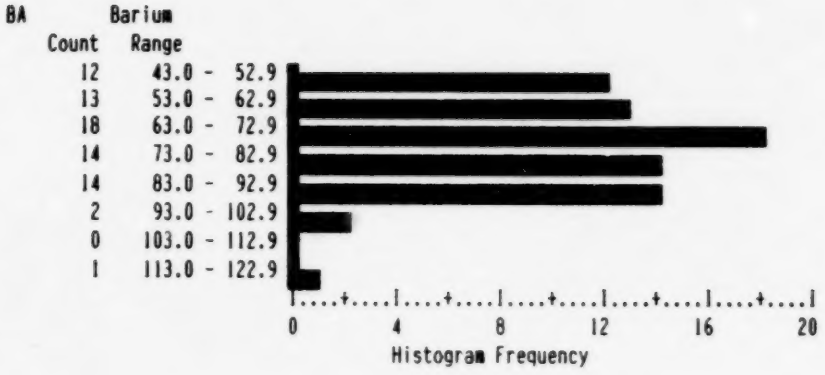


Histograms for Cu in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.

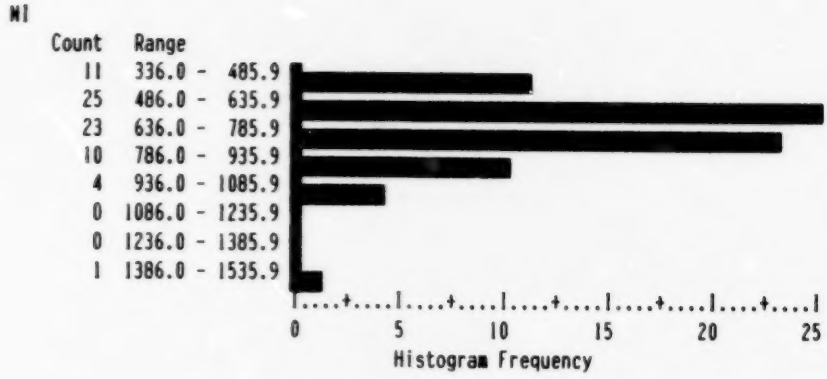


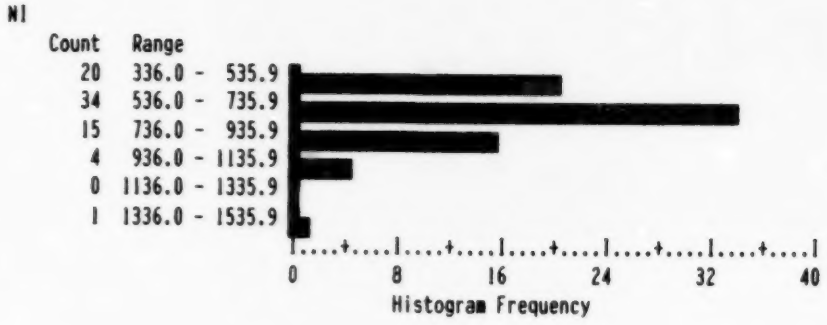


Histograms for Pb in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.

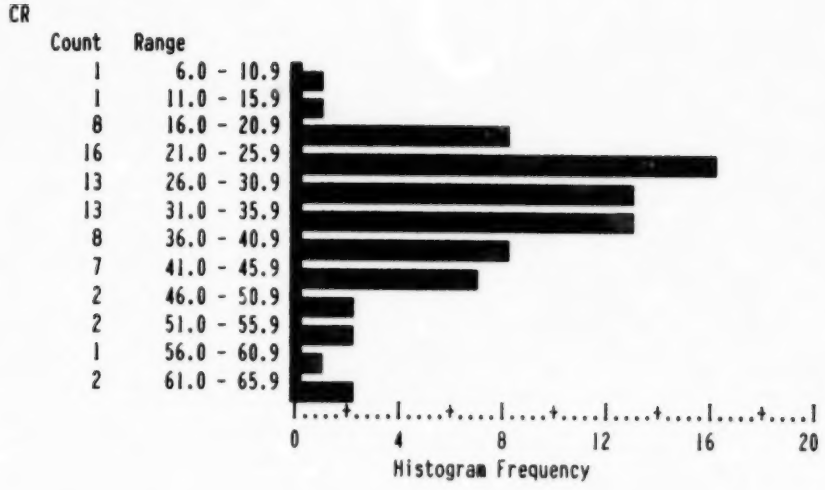


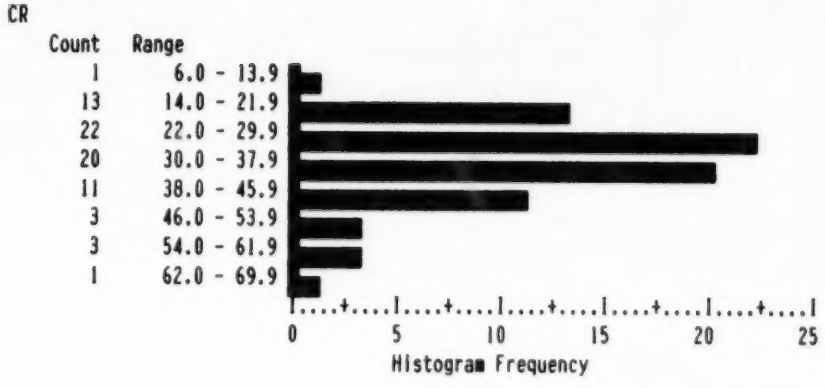
Histograms for Ba in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.



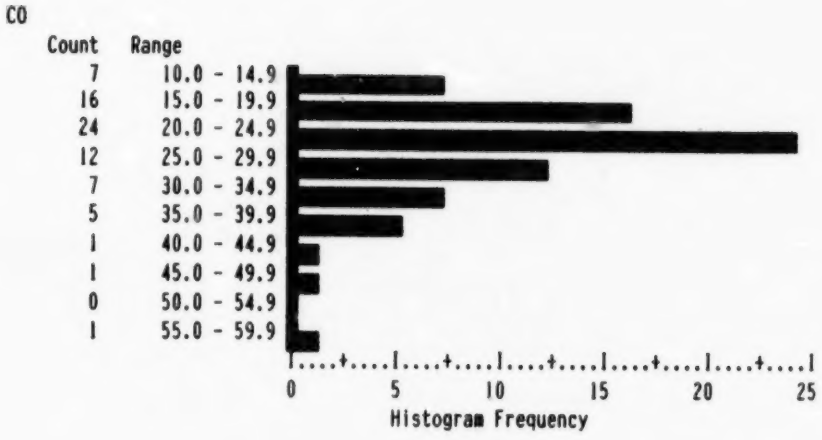


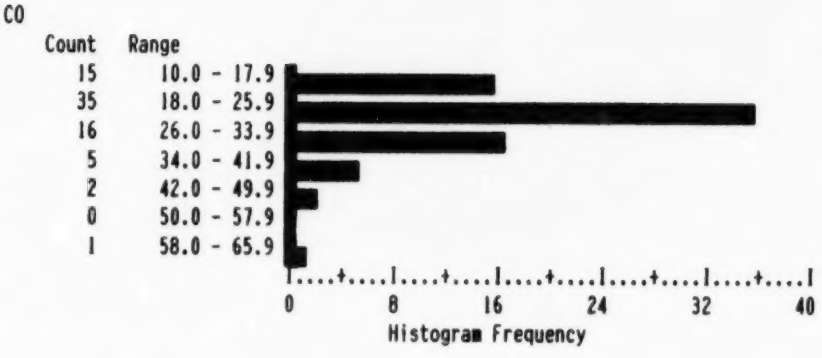
Histograms for Ni in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.



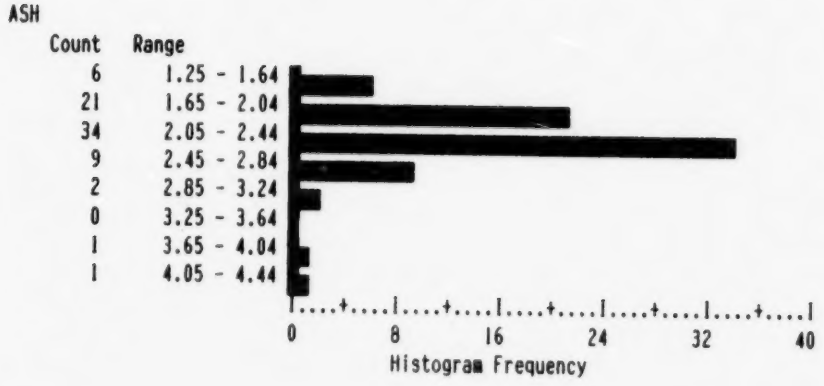


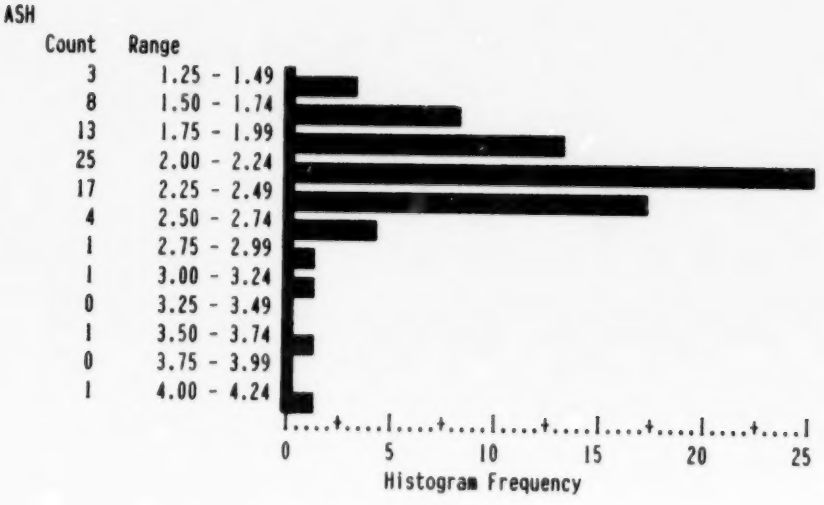
Histograms for Cr in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.





Histograms for Co in ash of black spruce bark samples, Rushed occurrence. Analysis by AAS.





Histograms for ash content in black spruce bark samples, Rushed occurrence.